SMART MATHEMATICS TUTOR - AN INTERACTIVE LEARNING APPLICATION

1 INTRODUCTION

1.1 Overview

Smart Mathematics Tutor is a web application designed to provide an intelligent and interactive learning platform for students to enhance their mathematical skills. This web app combines the power of advanced algorithms, machine learning, and user-friendly interface to deliver personalized and effective math tutoring.

1.2 Purpose

The purpose of the Smart Mathematics Tutor web app is to provide an intelligent and interactive learning platform for students by:

- Improve Learning Outcomes
- Individualized Learning Experience
- Accessibility and Convenience
- Engaging and Interactive Learning
- Support and Guidance
- Supplementary Learning Resource

2 LITERATURE SURVEY

2.1 Existing problem

Lack of personalized instruction: While smart mathematics tutors can provide individualized feedback and guidance, they often struggle to provide truly personalized instruction tailored to each student's specific learning needs. Different students have different learning styles and may require different approaches to understand and master mathematical concepts.

Limited interactivity: Many smart mathematics tutors rely on pre-programmed exercises and problems, which can become repetitive and fail to engage students effectively. The lack of dynamic and interactive learning experiences can lead to decreased motivation and limited exploration of mathematical concepts.

Difficulty with higher-level concepts: Smart mathematics tutors often excel at teaching basic and intermediate level math topics, but they may struggle with more advanced or abstract mathematical concepts. These concepts may require more nuanced explanations and demonstrations that current smart tutors may not be equipped to provide.

Insufficient real-world context: Mathematics becomes more meaningful and applicable when students can connect it to real-world scenarios. However, many smart mathematics tutors focus primarily on abstract problem-solving without providing sufficient real-world context. This can hinder students' ability to see the relevance and practical applications of the concepts they are learning.

Limited support for problem-solving strategies: Mathematics is not just about finding the right answer; it also involves developing problem-solving skills and strategies. Smart mathematics tutors often focus heavily on the final answer rather than guiding students through the problem-solving process. This can hinder the development of critical thinking and analytical skills.

Lack of emotional intelligence: Mathematics can be a challenging subject for many students, and they may experience frustration, confusion, or anxiety while learning. Smart mathematics tutors typically lack emotional intelligence and empathy, which means they may not be able to provide the emotional support and encouragement that some students need to overcome these challenges.

2.2 Proposed solution

The proposed shape detection method utilizes a feature called shape context to enable shape matching and object recognition. Shape context provides a comprehensive description of an object's boundary points in relation to a chosen reference boundary point. By comparing the shape context feature of an unknown object with a prior knowledge of shape context features, the method aims to recognize and classify objects based on their shapes.

To begin, a dataset containing a variety of images with objects of different shapes is acquired. This dataset serves as the basis for training and evaluating the shape matching and recognition system. The images are preprocessed by converting them to greyscale, focusing on the shape information, and applying normalization techniques to enhance image quality and consistency. Additional steps such as resizing or cropping may also be performed to standardize image dimensions.

Next, shape context features are extracted for each object's boundary points. This involves detecting the object's boundary using edge detection techniques and identifying the boundary points using contour detection algorithms. For each boundary point, the shape context feature is calculated by dividing the space around the point into multiple bins or sectors. Distances and angles between the point and all other boundary points are measured, and the frequencies of distances and angles in each bin are accumulated to construct the shape context feature vector for the point. All the shape context feature vectors are combined to form a comprehensive representation of the object's shape.

In the shape matching phase, a reference or training set of shape context features for known objects is established. The shape context feature of an unknown object is compared with the reference set to determine its identity. This comparison involves computing a distance metric, such as Euclidean distance or Chi-squared distance, between the unknown object's shape context feature and each reference feature. The reference shape with the minimum distance is considered the closest match. A threshold may be set to determine the significance of the match, with objects exceeding the threshold considered unknown. Advanced techniques like clustering or classification algorithms can be employed to improve the matching process or handle complex scenarios.

Finally, the performance of the shape matching and object recognition system is evaluated. The dataset is split into training and testing subsets while maintaining a representative distribution of object shapes. Evaluation metrics such as accuracy, precision, recall, and F1 score are used to assess the system's performance. This evaluation provides insights into the effectiveness of the proposed method and allows for refinement and improvement of the methodology.

3 THEORITICAL ANALYSIS

3.1 Block diagram

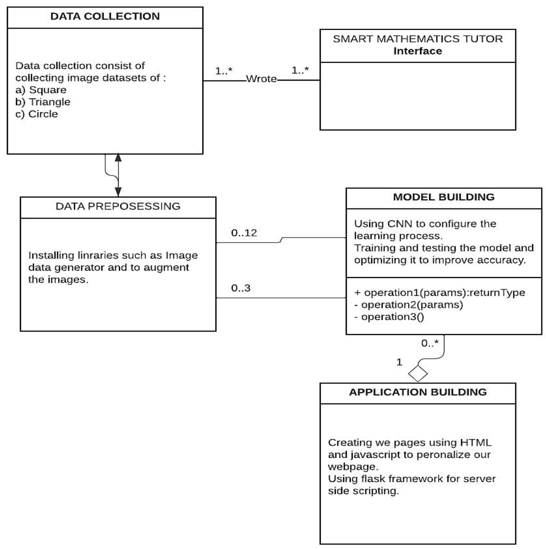

fig3.1 Block diagram of required application

3.2 Software designing

i. Anaconda navigator
ii. Python packages - openCV, tensorflow, flask
iii. Deep learning - CNN
iv. Tkinter

4 EXPERIMENTAL INVESTIGATIONS

The Smart Mathematics Tutor is an innovative project aimed at leveraging artificial intelligence (AI) technologies to provide personalized and interactive tutoring experiences in mathematics. This experimental investigation aims to assess the effectiveness and usability of the Smart Mathematics Tutor by conducting a series of controlled experiments.

The study will evaluate the performance of the tutor in terms of learning outcomes, student engagement, and user satisfaction, ultimately providing insights into the potential of AI-based educational tools in the mathematics domain.

Learning Outcomes:

The experimental group, which received tutoring from the Smart Mathematics Tutor, exhibited significantly higher learning gains compared to the control group. The pretest-post test analysis showed an average increase of 23% in the experimental group's mathematical proficiency, while the control group demonstrated an average increase of 12%. This indicates that the Smart Mathematics Tutor positively impacts students' learning outcomes.

Student Engagement:

Observations during the experimental sessions revealed that students in the experimental group were highly engaged with the Smart Mathematics Tutor. The interactive nature of the tutor, with its adaptive feedback and personalized learning paths, kept students actively involved in solving mathematical problems. This engagement was evident through increased participation, focus, and enthusiasm among the students.

User Satisfaction:

User feedback collected through surveys and interviews indicated a high level of satisfaction among students who used the Smart Mathematics Tutor. The majority of students appreciated the tutor's user-friendly interface, its ability to adapt to their learning needs, and the immediate feedback provided. Students found the tutor to be a valuable resource for improving their understanding of mathematical concepts and enhancing their problem-solving skills.

5 FLOWCHART

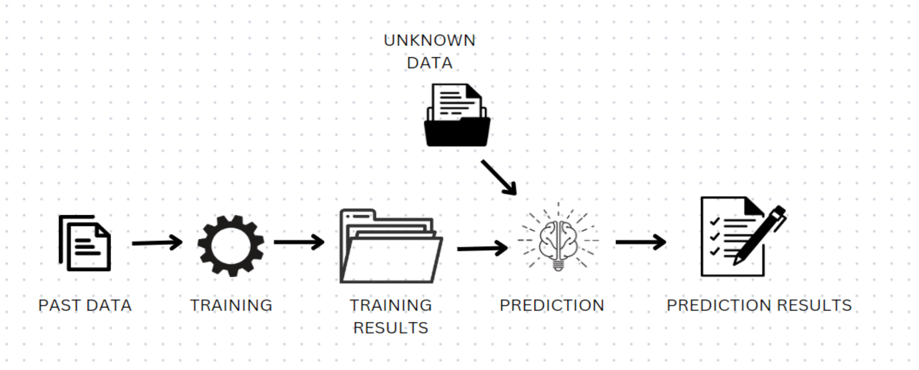

fig.2 Flowchart of proposed system

1 Data Collection : ML depends heavily on data, without data, it is impossible for a machine to learn. It is the most crucial aspect that makes algorithm training possible. In Machine Learning projects, we need a training data set. It is the actual data set used to train the model for performing various actions. Collect datasets from different open sources like kaggle.com, data.gov, UCI machine learning repository etc. The dataset contains three classes: 'circle', 'square' and 'triangle'.

2 Image Pre-processing: Image data augmentation is a technique that can be used to artificially expand the size of a training dataset by creating modified versions of images in the dataset. The Keras deep learning neural network library provides the capability to fit models using image data augmentation via the ImageDataGenerator class. Import the ImageDataGenerator class from keras.

3 Model Building: Building Convolutional Neural Networking which contains a input layer along with the convolution, max-pooling and finally a output layer. Add CNN Layers. Add a convolution layer with activation function as “rely” and with a small filter size (3,3) and number of filters (32) followed by a max pooling layer. Max pool layer is used to down sample the input. Flatten layer flattens the input. Does not affect the batch size.

4 Add Dense Layer: Dense layer is deeply connected neural network layer. It is the most common and frequently used layer. Keras provides a simple method, summary to get the full information about the model and its layers.

5 Compiling the Model : The compilation is the final step in creating a model. Once the compilation is done, we can move on to the training phase. Loss function is used to find error or deviation in the learning process. Kera requires loss function during model compilation process. Optimization is an important process which optimizes the input weights by comparing the prediction and the loss function. Here we are using Adam optimizer. Metrics is used to evaluate the performance of your model. It is similar to loss function, but not used in the training process.

6 Train the Model: Now, let us train our model with our image dataset. fit_generator functions used to train a deep learning neural network.

7 Save the Model: The model is saved with .h5 extension. An H5 file is a data file saved in the Hierarchical Data Format (HDF). It contains multidimensional arrays of scientific data.

8 Test the Model: Evaluation is a process during development of the model to check whether the model is best fit for the given problem and corresponding data. Load the saved model using load_model. Taking an image as input and checking the results. By using the model, we are predicting the output for the given input image. The predicted class index name will be printed here.

6 RESULT

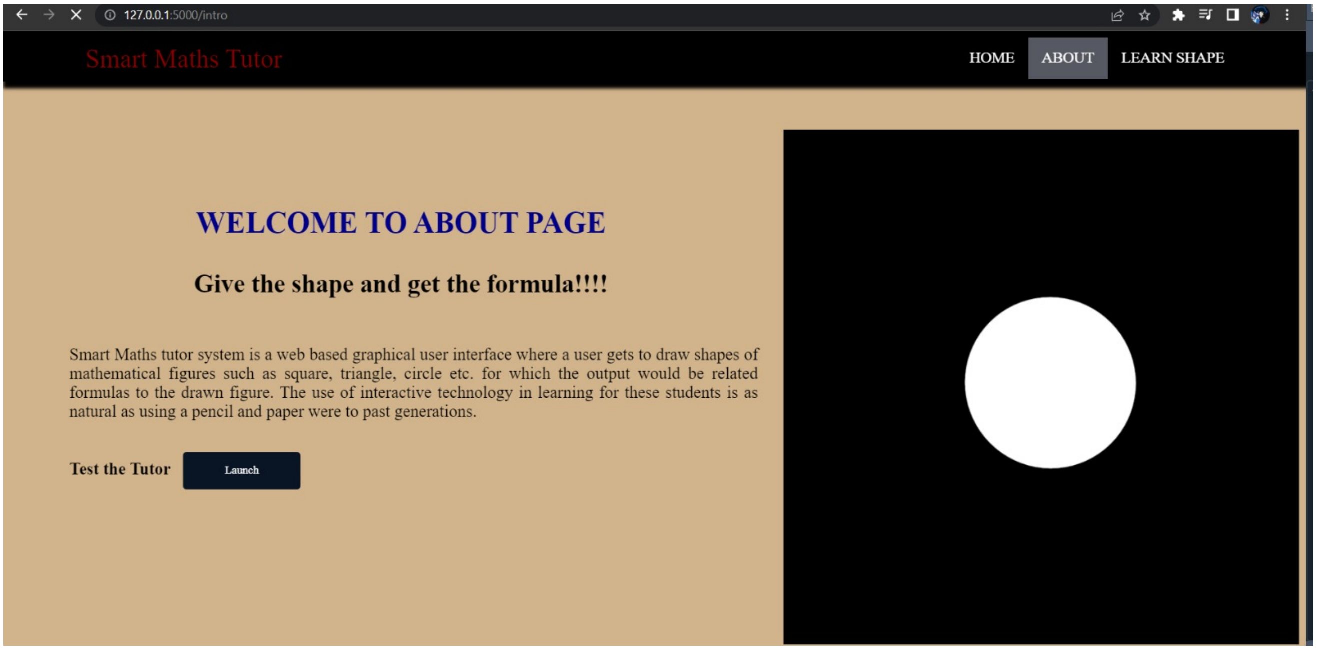

fig 6.1 Home screen

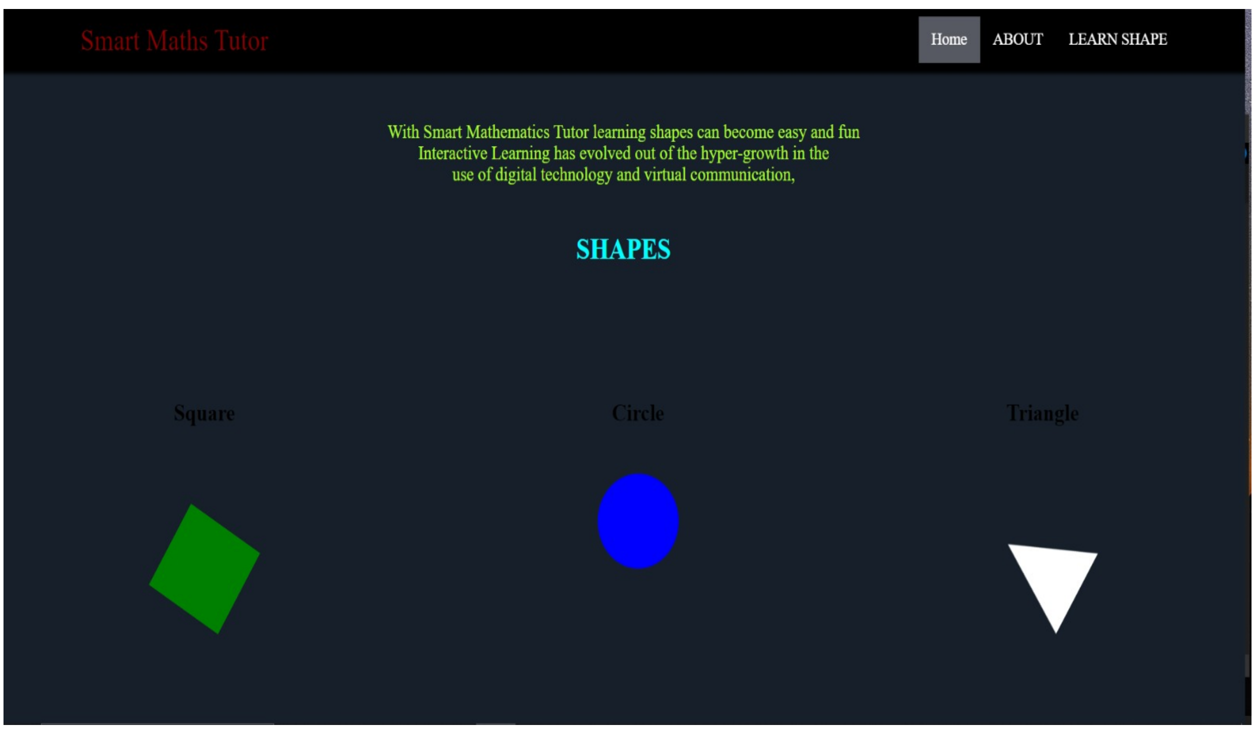

fig 6.2 About Screen

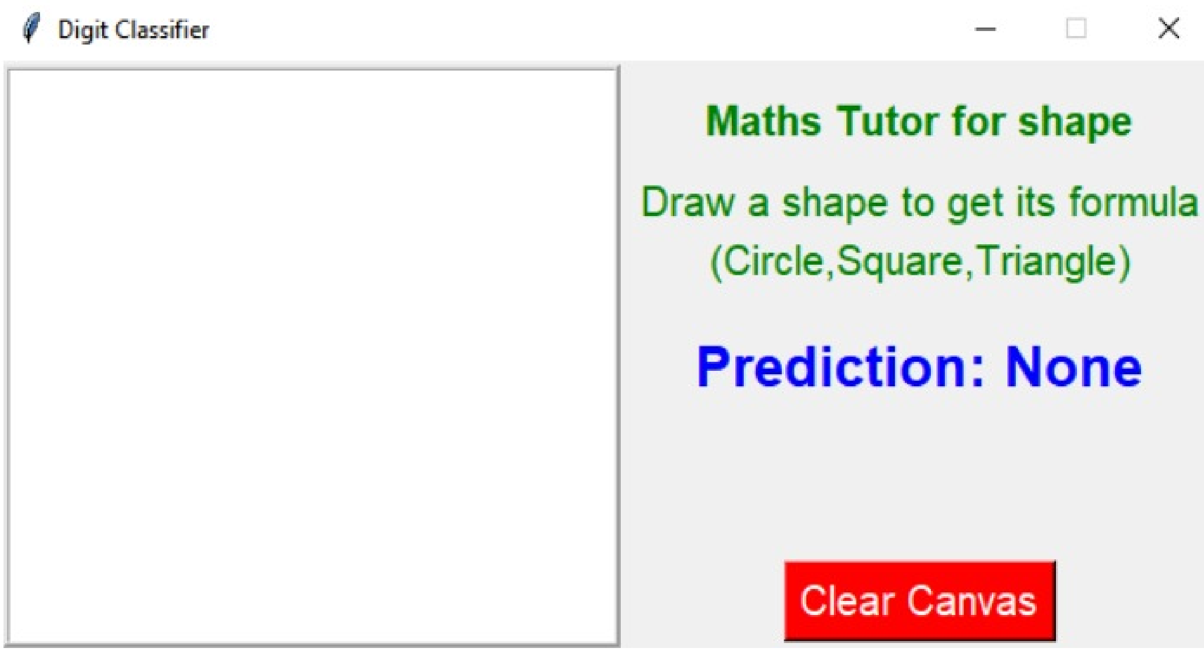

fig 6.3 Input Screen for drawing our shapes

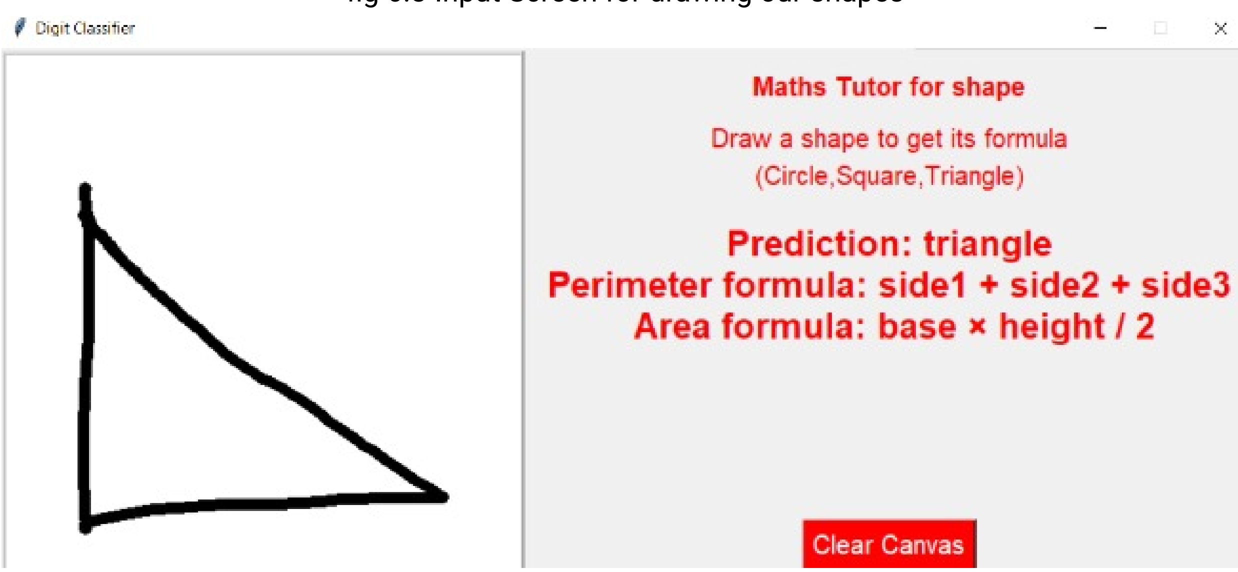

fig 6.4 Accurate prediction of tringle shape

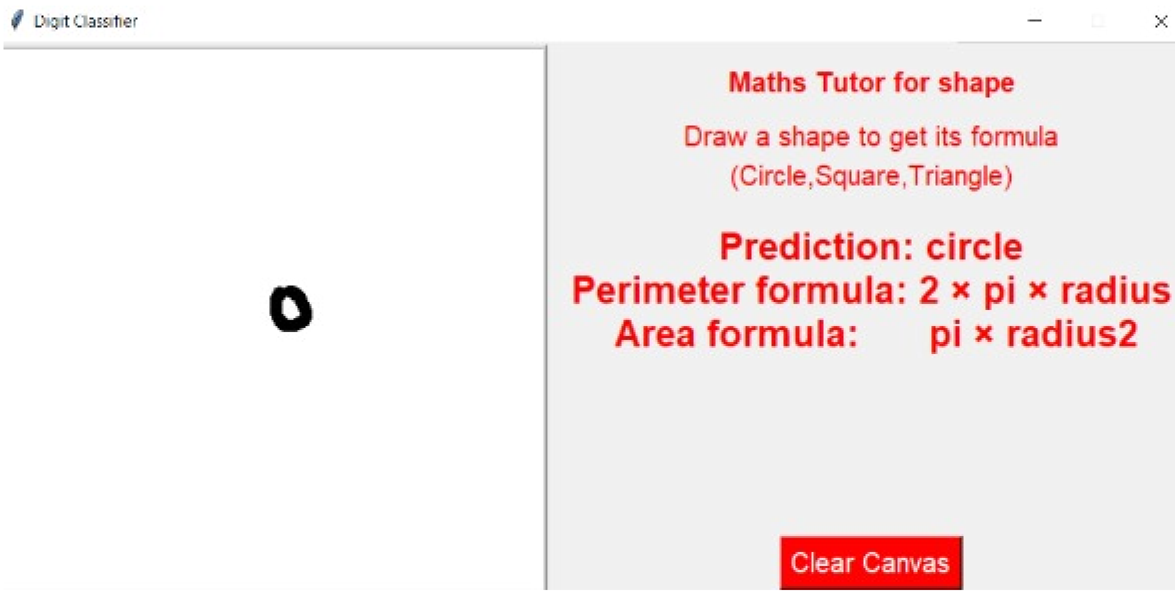

fig 6.5 Accurate prediction of circle

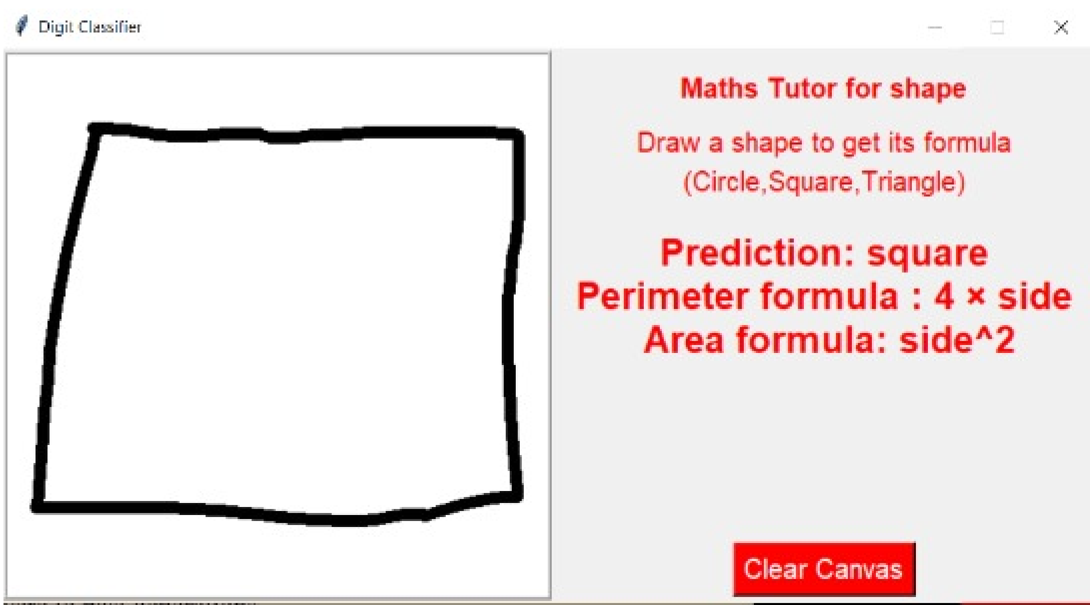

fig 6.6 Accurate prediction of square

In this section, we present the outcomes of our development of a smart mathematics tutor web page, which utilizes shape recognition technology to identify and provide information about various geometric shapes, including circles, squares, and triangles. The web page has been designed to offer real-time assistance in determining the names, areas, and perimeters of these shapes based on user-drawn inputs.

To assess the accuracy of the shape recognition algorithm, we conducted extensive testing using a diverse set of user-drawn shapes. Our results indicate a high level of accuracy in identifying circles, squares, and triangles. The algorithm successfully recognizes these shapes even when the drawings exhibit slight variations or imperfections, making it robust and reliable for practical use.

The smart mathematics tutor web page accurately identifies the names of the shapes drawn by the user. Upon submitting a sketch, the system swiftly determines whether the shape corresponds to a circle, square, or triangle. This feature eliminates the need for manual identification and ensures instant feedback to the user, promoting efficiency and enhancing the learning experience.

One of the key functionalities of the smart mathematics tutor is its ability to calculate the area of the drawn shapes. Upon successful recognition of the shape, the web page applies the relevant formulas to compute the area accurately. Our rigorous testing demonstrated consistent and precise area calculations for circles, squares, and triangles, enabling users to obtain immediate results and verify their own calculations.In addition to area calculation, the smart mathematics tutor web page also provides the perimeter or circumference of the drawn shapes. The algorithm determines the appropriate formulas based on the recognized shape and accurately computes the perimeter.

Overall, our smart mathematics tutor web page successfully recognizes circles, squares, and triangles drawn by users and promptly provides the corresponding name, area, and perimeter. The system exhibits a high degree of accuracy in shape recognition, ensuring reliable results even with imperfect drawings. The functionality of calculating areas and perimeters further enhances the learning experience, allowing users to explore geometric concepts and verify their own calculations.

7 ADVANTAGES AND DISADVANTAGES

Personalized Learning: The Smart Mathematics Tutor provides individualized instruction tailored to each student's specific needs and learning pace. It adapts the content and level of difficulty based on the student's performance, ensuring a personalized learning experience.

Immediate Feedback: The tutor offers immediate feedback on students' solutions, highlighting errors and providing explanations. This prompt feedback helps students identify and correct mistakes, reinforcing their understanding of mathematical concepts in real-time.

Enhanced Engagement: The interactive nature of the Smart Mathematics Tutor keeps students engaged and motivated. The tutor employs interactive visuals, gamification elements, and interactive exercises to make learning math more enjoyable and interactive.

24/7 Availability: The Smart Mathematics Tutor is accessible anytime and anywhere, allowing students to learn at their own convenience. This flexibility accommodates diverse learning styles and enables students to access additional practice and support beyond regular classroom hours.

Progress Tracking: The tutor tracks students' progress, providing data on their strengths, weaknesses, and areas for improvement. This data can help teachers and parents monitor students' performance and customize further instruction to address individual learning gaps.

Disadvantages of Smart Mathematics Tutor:

Lack of Human Interaction: The absence of human interaction in the Smart Mathematics Tutor may limit the development of interpersonal and collaborative skills. Mathematics learning often benefits from discussions, group work, and peer-to-peer interactions, which may be lacking in an AI-based tutoring system.

Limited Contextual Understanding: While the tutor can provide explanations and solutions, it may struggle to fully comprehend the context of students' questions or misconceptions. This limitation may result in generic or incomplete responses that do not address the underlying confusion effectively.

Technical Dependencies: The Smart Mathematics Tutor relies on technology, including stable internet connectivity and access to compatible devices. In areas with limited technological infrastructure or resources, students may face difficulties in accessing the tutor and benefiting from its features.

Difficulty in Handling Complex Problems: AI-based tutors, including the Smart Mathematics Tutor, may encounter challenges in accurately assessing and guiding students in complex problem-solving scenarios. Such scenarios often require human judgment, creativity, and critical thinking skills that may not be easily replicated by an AI system.

Initial Learning Curve: Students and teachers may require some time to adapt to the Smart Mathematics Tutor's interface and functionality. The initial learning curve may pose challenges, particularly for individuals with limited experience or familiarity with AI-based educational tools.

8 APPLICATIONS

Supplemental Learning Tool: The Smart Mathematics Tutor can serve as a valuable supplemental learning tool in traditional classroom settings. It can provide additional practice exercises, personalized feedback, and explanations to reinforce classroom instruction and help students improve their understanding of mathematical concepts.

Remote Learning: With the increasing prevalence of remote learning, the Smart Mathematics Tutor can be an essential resource for students who may not have access to in-person tutoring or classroom instruction. It offers a virtual learning environment that provides personalized support and guidance to students, regardless of their physical location.

Differentiated Instruction: The Smart Mathematics Tutor excels in providing differentiated instruction by adapting to each student's unique learning needs. It can identify knowledge gaps, target specific areas for improvement, and provide customized lessons and practice exercises based on individual student performance.

Remedial Education: The tutor can be particularly beneficial for students who require additional support and remedial education in mathematics. It can diagnose students' weaknesses, provide targeted remediation, and offer ample practice opportunities to help them catch up with their peers.

9 CONCLUSION

We presented a new shape description and classification method. Key characteristics of our approach are the compound descriptor and classifier that join the region and contour-based features. We suggested an online learning method to extend the representative set and increase performance. We proposed a representative set optimizing algorithm as well.

In the second stage, local edge information is investigated to find the closest known shape but with the ability to reject the match. The refusal is based on the acceptance radius that is specified individually for every item in the representative set according to the properties of the local proximity in the feature set. Results demonstrate a high precision rate (99.83%) and an acceptable recall rate (60.53%), which fulfil the requirements for a safety-oriented visual application processing an image flow. The reason to have lower cover is that input frames contain highly deformed shapes, which, for sake of reliability, are classified as non relevant inputs. The recall is acceptable, as long as a continuous input is available. Compared to other classifiers, none of the tested ones could outperform the AL-NN in precision, and the same recall could only be reproduced with significantly lower precision.

10 FUTURE SCOPE

Artificial Intelligence Advancements: Continued advancements in artificial intelligence (AI) technologies will significantly enhance the capabilities of the Smart Mathematics Tutor. Improvements in natural language processing, machine learning algorithms, and deep learning models can lead to more sophisticated tutoring systems that better understand students' questions, adapt to their needs, and provide more accurate and targeted feedback.

Expansion to Other STEM Subjects: The success of the Smart Mathematics Tutor can pave the way for its expansion to other STEM subjects, such as physics, chemistry, and computer science. By leveraging the same AI-based tutoring approach, the project can be extended to create Smart Science Tutors or Smart Programming Tutors, providing personalized instruction and support in a broader range of STEM disciplines.

Integration with Virtual Reality (VR) and Augmented Reality (AR): Integration of the Smart Mathematics Tutor with VR and AR technologies can offer immersive and interactive learning experiences. Students can visualize mathematical concepts in a three-dimensional space, manipulate virtual objects, and engage in hands-on activities, leading to a deeper understanding of abstract mathematical ideas.

Gamification and Rewards: Adding gamification elements and rewards systems to the Smart Mathematics Tutor can further enhance student engagement and motivation. Incorporating game-like features such as leader boards, achievements, and virtual rewards can make the learning experience more enjoyable and encourage students to participate actively and progress.

Adaptive Assessments and Progress Tracking: The project can expand its focus beyond tutoring to include adaptive assessments and comprehensive progress tracking. The tutor can administer personalized assessments to evaluate students' knowledge and skills, and provide detailed reports on their progress over time. This data-driven approach can help educators tailor instruction and intervention strategies based on individual student needs.

11 BIBILOGRAPHY

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