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Research Article

Classification Of Image Corner Point Detection System To Identify A Shape Using The Viola Jones Method

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Abstract: Along with the times, computer technology is developing very rapidly. The increasingly rapid development of computer technology means that everyone is required to utilize computer technology in their daily lives. Utilization of technology is one of the implementation roles of scientific disciplines. The reason behind the formation of this research is so that in the future it will become a fun learning concept in the introduction of objects and shapes in children and the motor development of children. children are usually more interested in seeing pictorial text, or pictures that contain lots of color. The Viola Jones method itself was chosen as the research completion algorithm. The Viola Jones method is usually used as a method in research that discusses the detection of objects, faces and others. The Viola Jones method was chosen because it has a high level of accuracy that can reach 100% probability.

Keywords: AdaBoost; Computer Vision; Digital Image Processing; Shape Detection; Viola–Jones Method.

1. Introduction

The rapid advancement of computer technology has encouraged its utilization in various aspects of daily life. The application of technology represents one form of implementing scientific knowledge to address a wide range of problems. One area that has experienced significant growth is digital image processing, which is used to process images so that they can be analyzed and interpreted by computer systems. Digital image processing began to gain attention in the early 1920s and experienced substantial development around the 1960s with the emergence of computer technology capable of providing the processing speed and memory capacity required by image processing algorithms. Since then, numerous applications have been developed to utilize computer capabilities in processing both images and videos. Modern computer systems are no longer limited to graphic design and multimedia applications but are also widely applied in object recognition and pattern analysis tasks within digital images.

One application of digital image processing is object identification, including shape recognition. Object detection is one of the most widely studied topics in the field of computer vision because it aims to determine the presence of an object within a digital image. Although object recognition appears straightforward for humans, it is considerably more complex when performed by computer systems. This complexity arises from several factors, including object location, viewing angle, lighting conditions, and occlusion. Consequently, effective methods

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are required to detect and identify objects accurately under various image conditions and environments.

Shape detection plays a crucial role because it serves as the initial stage in the object identification process. The effectiveness of the detection stage directly influences the success of subsequent recognition processes. In practice, shape recognition is often conducted manually, where teachers introduce geometric shapes by drawing them on a whiteboard. This condition motivated the development of the present study. In addition, children are generally more attracted to visual learning media, such as colorful images and illustrated text. Therefore, a system capable of providing a more engaging and interactive approach to shape recognition is needed to support the learning process and contribute to children's motor skill development.

Based on the identified problems, shape identification systems are still largely conventional and manual. Furthermore, studies focusing on shape detection as a learning medium for toddlers remain limited. Previous studies have also reported challenges related to identification accuracy, particularly when images are captured under non-ideal conditions, such as poor lighting, shadows, blurred images, and unclear object appearances. These issues may affect image interpretation and reduce the accuracy of object recognition. In addition, there is currently no system specifically designed to introduce geometric shapes to toddlers using the Viola–Jones method. Therefore, this study focuses on developing a shape detection system based on the Viola–Jones method to provide accurate object detection while serving as an enjoyable educational medium for introducing shapes to children.

The Viola–Jones method was selected because it is widely used in object detection research and is known for its high level of accuracy. This method utilizes Haar-like features as descriptors and combines integral image representation with the AdaBoost algorithm to perform feature selection and object classification. Through this combination, the Viola–Jones method is capable of detecting objects efficiently with relatively fast computational performance. Based on these considerations, this study proposes an image corner-point detection system for identifying geometric shapes using the Viola–Jones method as an effort to support the development of digital image processing–based educational media.

2. Literature Review

Classification

Classification is the process of grouping objects based on their similarities and differences into specific categories or classes. In scientific disciplines, classification is used to organize and categorize objects systematically so that they can be more easily recognized, studied, and understood. The primary objective of classification is to facilitate the identification and understanding of objects through a structured grouping process.

In everyday life, classification is commonly encountered in various contexts. For example, goods in a marketplace are grouped according to their categories, while in scientific research, objects are classified based on specific characteristics. Classification generally aims to organize information systematically, making it easier for users to access, analyze, and interpret data.

Classification methods can be divided into several approaches. The empirical method groups objects alphabetically without considering their characteristics or relationships. In contrast, the rational method classifies objects based on clearly defined characteristics and relationships. The rational approach includes practical systems, artificial systems, natural systems, and modern systems that incorporate genetic or advanced characteristic analyses. Through these approaches, classification contributes significantly to organizing knowledge and facilitating decision-making processes.

Computer Vision

Computer vision is a field of study that focuses on enabling computers to recognize, analyze, and interpret visual information from images or videos. According to the concept proposed by Linda Shapiro, computer vision aims to simulate human visual perception through computational systems. The objective is to enable computers to understand visual content and make decisions based on the information obtained from images.

Computer vision consists of two primary areas: image processing and pattern recognition. Image processing focuses on improving image quality to facilitate analysis by humans or machines. This process may involve image enhancement, filtering, and transformation techniques. Pattern recognition, on the other hand, is concerned with automatically identifying and classifying objects, symbols, or patterns within an image. Through the integration of these two components, computer vision systems can perform object detection, classification, and recognition tasks effectively.

The development of computer vision has enabled its application in numerous fields, including object detection, facial recognition, medical image analysis, surveillance systems, and educational technologies. In this study, computer vision serves as the fundamental framework for recognizing and identifying geometric shapes from digital images.

Viola–Jones Method

The Viola–Jones method is a widely used object detection algorithm that performs image classification based on feature values extracted from an image. Instead of relying directly on pixel values, the method utilizes specific image features that represent meaningful visual characteristics. This approach enables faster processing and more efficient object detection compared to pixel-based methods.

One of the main advantages of the Viola–Jones method is its ability to encode visual information through simple yet effective features. The algorithm employs Haar-like features to represent differences in intensity between adjacent image regions. These features allow the system to identify structural patterns within an image that correspond to the target object.

To improve computational efficiency, the Viola–Jones method uses an Integral Image representation, which enables rapid calculation of feature values across different image regions. Furthermore, the method incorporates the AdaBoost algorithm to select the most relevant features and combine multiple weak classifiers into a stronger classifier. Through this process, the system can effectively distinguish between object and non-object regions.

The use of feature-based classification significantly reduces processing time while maintaining a high level of detection performance. Consequently, the Viola–Jones method has been widely adopted in various object detection applications and serves as the primary method employed in this study for identifying geometric shapes from digital images.

3. Materials and Method

Research Data

This study utilized a public dataset collected from various internet sources to support the implementation and evaluation of the proposed system. To ensure a structured research process and achieve a high level of detection accuracy, the dataset consisted of ten images divided into two categories, namely five training images and five testing images. The training images were used to train the detection model, while the testing images were employed to evaluate the performance of the implemented system.

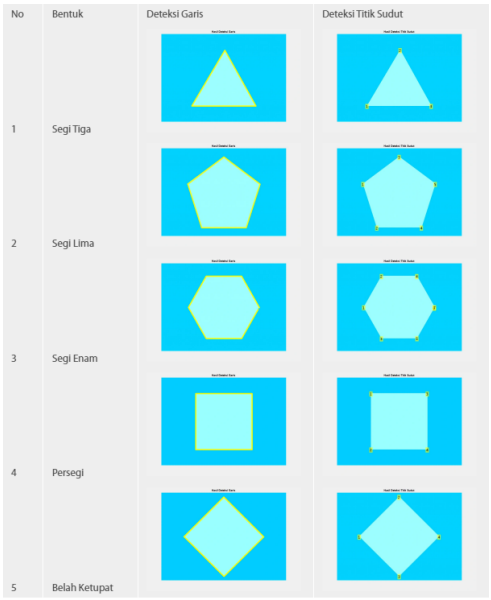

Figure 1. Research Dataset

Research Method

This study employed the Viola–Jones method for shape detection and identification. The Viola–Jones algorithm performs image classification based on feature values extracted from an image. The method was selected because feature-based processing is computationally faster than pixel-based classification and is capable of producing accurate detection results.

The implementation of the Viola–Jones method consists of four main stages: Haar-like Feature extraction, Integral Image computation, AdaBoost learning, and object classification. These stages work together to identify the presence of shapes within digital images.

Haar-like Feature Extraction

The first stage of the Viola–Jones method is the extraction of Haar-like features. These features represent differences in pixel intensity between adjacent image regions and are used to describe the characteristics of an object. Several rectangular feature patterns are applied to determine the existence of a shape within an image.

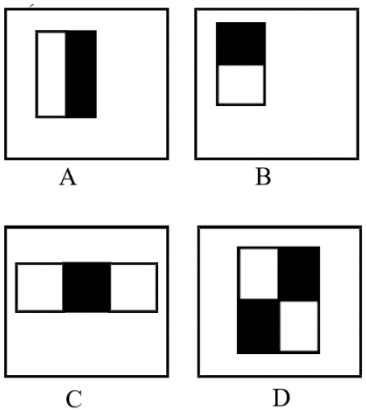

Figure 2. Haar-like Feature Types

The feature value is calculated by subtracting the sum of pixel values in the dark region from the sum of pixel values in the bright region. The resulting value is then used as a descriptor for object detection.

Integral Image

To accelerate feature computation, the Viola–Jones algorithm employs the Integral Image technique. An integral image is generated by accumulating pixel values from the top-left corner to a specified image location. This approach significantly reduces the computational cost of calculating Haar-like features.

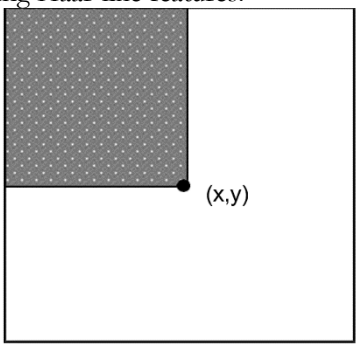

Figure 3. Integral Image Representation.

The integral image value is computed using the following equation:

$$\boldsymbol{D = (A + B + C + D) - (A + B) - (A + C) + A}$$

Through this approach, feature values can be obtained efficiently without performing repetitive pixel-by-pixel calculations.

AdaBoost Learning

After feature extraction, the AdaBoost algorithm is applied to select the most relevant features and construct a strong classifier. AdaBoost combines multiple weak classifiers and assigns weights to each classifier according to its classification performance. The resulting strong classifier is then used to distinguish shape objects from non-shape objects.

This process enables the system to improve detection performance by focusing on the most discriminative features extracted from the training images.

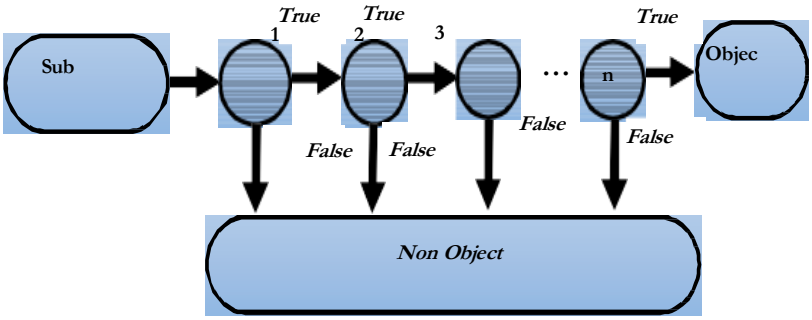

Figure 4. Viola–Jones Detection Process

The output of this stage is the identification result of the detected shape within the input image. The detected object is subsequently used as the basis for evaluating the effectiveness of the proposed system.

Testing Design

System evaluation was conducted using the Black Box testing approach. In this method, various input conditions were provided to the application, and the resulting outputs were compared with the expected outcomes. The system was considered valid if it successfully

performed image input, feature description, and shape classification processes without generating errors.

The testing scenarios included training image input validation, testing image input validation, and validation of the shape description and classification process.

4. Results and Discussion

System Implementation

The proposed shape detection system was developed using the Viola–Jones method to identify geometric shapes from digital images. The implementation process consisted of image acquisition, feature extraction, image integration, classifier training, and shape detection. The system utilized public datasets consisting of training and testing images to evaluate the detection process.

The developed system allows users to upload an image and perform shape detection automatically. During the detection process, the system analyzes image features using Haar-like features and computes feature values through the Integral Image approach. The extracted features are subsequently evaluated using the AdaBoost classifier to determine the existence of a shape within the image. The overall process demonstrates the implementation of the Viola–Jones algorithm for shape recognition and identification.

Figure 5. System Workflow for Shape Detection

Image Processing Results

The image processing stage began with the acquisition of input images. Each image was converted into a format suitable for feature extraction and analysis. The system then performed image integration to accelerate feature calculation and improve computational efficiency.

The Integral Image representation enabled the system to calculate feature values by utilizing a reduced number of pixel computations. This process contributed to a more efficient detection mechanism and supported the extraction of significant image characteristics

required for shape recognition. The resulting integrated image was subsequently used during the feature selection and classification stages.

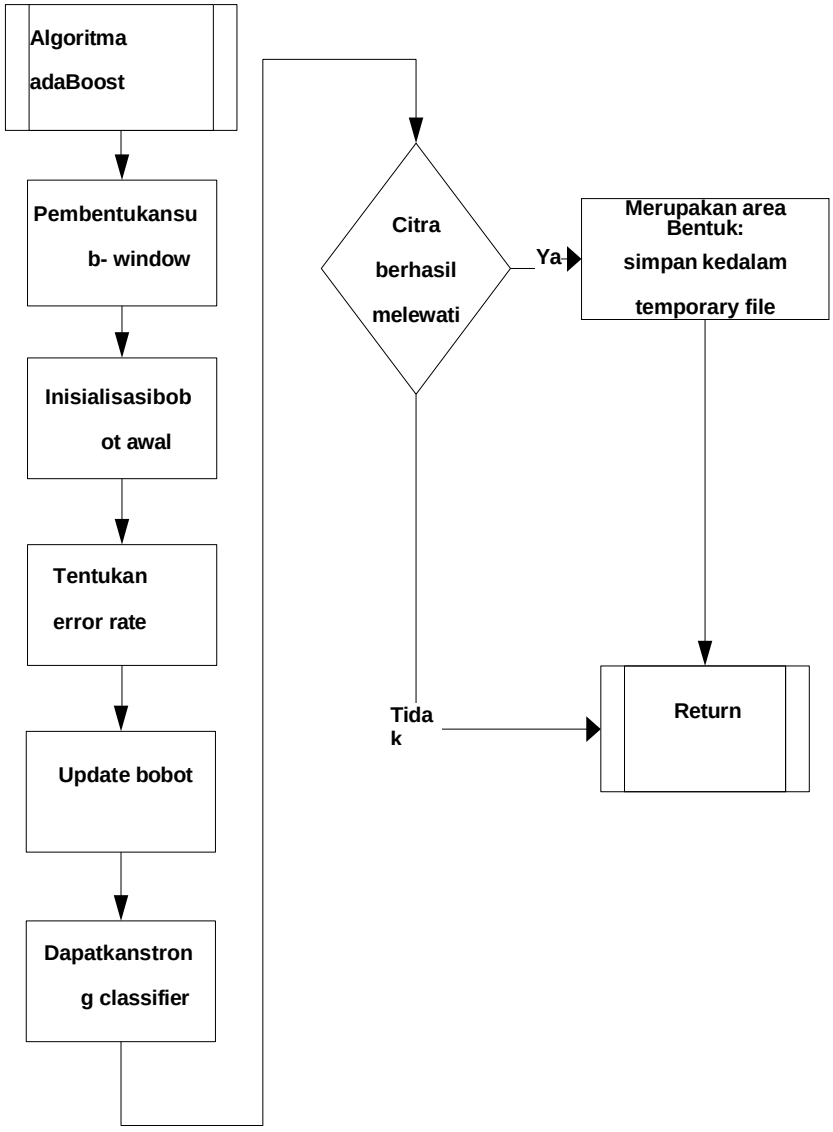

Figure 6. Flowchart Algoritma AdaBoost

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	2	4	3	5	2	6	8	5	8	9	9	4	4	5	6	5	6	5	7
2	4	3	5	6	7	4	6	10	4	3	11	3	12	4	2	5	34	6	7
3	6	7	4	5	5	5	6	6	7	7	7	7	8	8	9	9	7	8	8
4	6	7	4	5	5	5	6	6	7	7	7	7	8	8	9	9	8	5	5
5	6	7	4	5	5	5	6	6	7	7	7	7	8	8	9	9	8	6	21
6	6	7	4	5	5	5	6	6	7	7	7	7	8	8	9	9	7	7	22
7	6	7	4	5	5	5	6	6	7	7	7	7	8	8	9	9	8	8	6
8	5	7	6	5	5	3	2	5	3	12	3	5	5	5	5	6	4	3	4
9	7	3	1	7	3	5	4	2	6	4	7	8	9	8	2	2	4	7	7
10	6	4	2	1	4	4	6	3	7	8	5	6	7	4	6	5	5	5	3
11	5	5	5	5	5	5	7	4	2	6	7	8	5	9	7	4	6	7	2
12	4	3	2	1	7	2	3	6	4	3	5	6	4	5	6	3	7	7	5
13	8	4	23	14	5	7	9	8	7	5	5	5	8	7	7	4	7	7	7
14	9	6	3	0	7	5	7	5	6	3	6	8	7	9	3	23	13	4	6

15	15	7	1	9	4	6	2	7	8	6	7	7	8	9	9	4	7	8	5
16	6	8	10	12	4	6	2	7	8	6	7	7	8	9	9	3	7	7	6
17	5	6	7	8	4	6	2	7	8	6	7	7	8	9	9	2	8	8	45
18	8	8	8	8	4	6	2	7	8	6	7	7	8	9	9	2	8	8	6
19	9	7	5	3	3	4	6	5	7	8	5	4	7	8	8	1	8	8	5
20	9	8	7	6	4	5	3	6	4	5	5	5	6	7	7	8	9	8	4

Figure 7. Original Values in Sub-indo Simulation Images

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	2	8	9	10	17	23	31	36	44	53	62	66	70	75	81	86	92	97	104
2	6	13	21	32	41	51	65	80	92	104	124	131	147	156	164	174	214	225	239
3	12	26	38	54	68	83	103	124	143	162	189	203	227	244	261	280	327	346	368
4	18	39	55	76	95	115	141	168	194	220	254	275	307	332	358	386	441	465	492
5	24	52	72	98	122	147	81	212	245	278	319	347	387	420	455	492	555	585	633
6	30	65	89	120	149	179	217	256	296	336	384	419	467	508	552	598	668	705	775
7	36	78	106	142	176	211	255	300	347	394	449	491	547	596	649	704	782	827	903
8	41	91	111	315	204	242	288	338	388	447	505	552	613	667	725	786	868	916	996
9	48	142	135	183	225	268	318	370	426	489	554	609	679	741	801	864	950	1005	1092
10	54	200	213	196	242	289	345	400	463	534	604	665	742	808	874	942	1033	1093	1183
11	59	122	162	216	267	319	382	441	506	583	660	729	811	886	959	1031	1128	1195	1287
12	63	188	197	226	284	338	404	469	538	618	700	775	861	941	1020	1095	1199	1273	1370
13	71	263	295	275	338	399	474	547	623	708	795	875	969	1056	1142	1221	1332	1413	1517
14	80	161	201	293	363	429	511	589	671	759	852	940	1041	1137	1226	1328	1452	1537	1647

15	95	263	290	325	399	471	555	640	730	824	924	1019	1128	1233	1331	1437	1568	1661	1776
16	101	372	409	361	439	517	603	695	793	893	1000	1102	1219	1333	1440	1549	1687	1787	1908
17	106	221	258	387	469	553	641	740	846	952	1066	1175	1300	1423	1539	1650	1796	1904	2070
18	114	343	368	419	505	595	685	791	905	1017	1138	1254	1387	1519	1644	1757	1911	2027	2199
19	123	473	503	443	532	626	722	833	954	1074	1200	1320	1460	1600	1733	1847	2009	2133	2310
20	132	270	291	473	566	665	764	881	1006	1131	1262	1387	1533	1680	1820	1942	2113	2245	2426

Figure 8. Integral Image Representation

Shape Detection Results

After the feature extraction and classification processes were completed, the system successfully detected shapes contained within the testing images. The detection results demonstrated that the Viola–Jones method was capable of recognizing shape patterns through the analysis of image features and classification procedures.

The implemented application provided a user interface that allowed image uploading and visualization of the detection results. The detected shapes were displayed as the final output of the system, indicating that the implemented method successfully performed the intended recognition task.

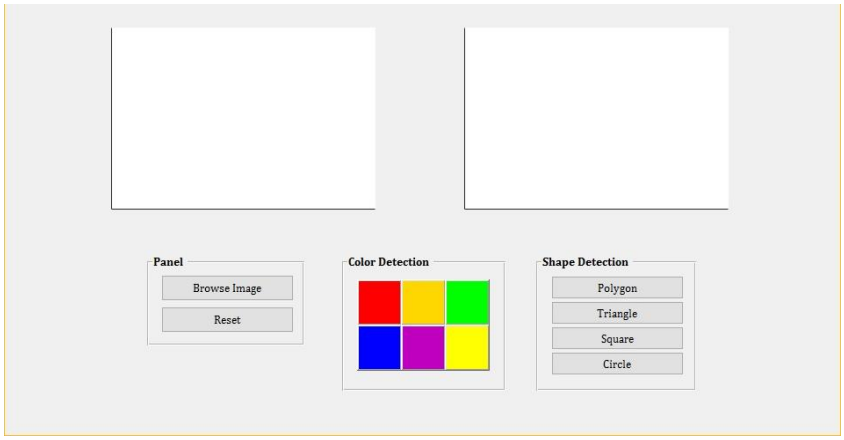

Figure 9. Home Screen View

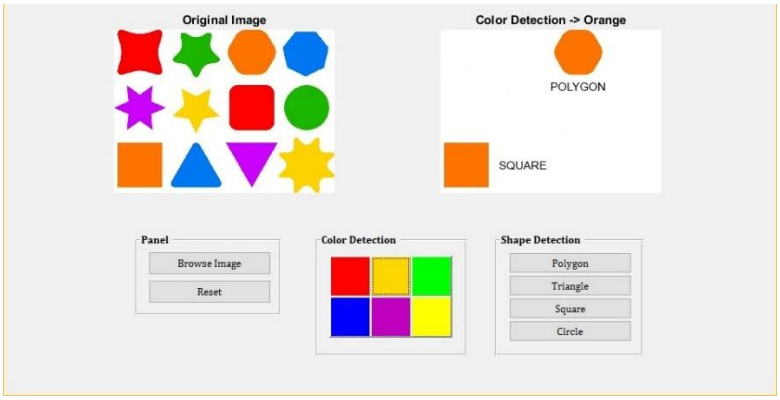

Figure 10. Tampilan Pendeteksian Bentuk.

System Testing Results

System testing was conducted using the Black Box testing approach. The evaluation focused on validating the functionality of image input, testing image input, and the shape description and classification processes. The testing results indicated that all functional scenarios were executed successfully and produced outputs consistent with the expected results.

The successful validation of all testing scenarios demonstrates that the developed application was capable of processing training images, testing images, and shape classification operations without generating system errors.

No	Skenario Penguji	Test Case	Hasil yang diharapkan	Hasil Pengujian	kesimpulan
1	Fungsi Menginput Data Latih	Validasi Data Latih	Mampu melakukan penginputan citra data latih	Sesuai	Valid
2	Fungsi Menginput Data Uji	Validasi Data Uji	Sistem mampu melakukan penginputan citra data uji	Sesuai	Valid
3	Sistem Melakukan Deskripsi Pada Citra Latih dan Citra Uji	Validasi sistem melakukan deskripsi	Sistem mampu melakukan Deskripsi dan Klasifikasi Pada Citra Latih Dan Citra Uji	Sesuai	Valid

Discussion

The implementation of the Viola–Jones method in this study demonstrated its applicability for shape detection and recognition within digital images. The method employs Haar-like features to represent visual characteristics of shapes and uses Integral Image computation to improve processing efficiency. By reducing the number of pixel operations required during feature calculation, the system was able to perform image analysis more efficiently than conventional pixel-based approaches.

The use of Integral Image significantly simplified the calculation of feature values. Instead of computing all pixel values within a region, the method utilized only several reference points to obtain the required information. This approach reduced computational complexity and accelerated the overall detection process. The experimental implementation confirmed that the Integral Image stage contributed to efficient feature extraction and classification.

The AdaBoost algorithm played an important role in selecting the most relevant features and constructing a strong classifier from multiple weak classifiers. Through this mechanism, the system was able to distinguish shape objects from non-shape objects based on the extracted features. The integration of Haar-like features, Integral Image, and AdaBoost created a complete detection framework that supported the identification of geometric shapes within digital images.

The testing results demonstrated that the developed application successfully performed image input, image processing, and shape classification functions. All testing scenarios produced outputs consistent with the expected results, indicating that the system operated correctly and fulfilled its intended functionality. These findings suggest that the Viola–Jones method can be implemented as a computerized approach for introducing geometric shapes and supporting educational activities related to shape recognition.

6. Conclusion

This study successfully implemented the Viola–Jones method for detecting and identifying geometric shapes from digital images. The developed system utilized Haar-like features, Integral Image, and AdaBoost learning to perform the shape detection process. Through the integration of these components, the system was able to process training and testing images and identify shape patterns contained in the input images.

The implementation results demonstrated that the proposed system was capable of performing image input, image processing, feature extraction, and shape classification functions in accordance with the expected system requirements. Based on the Black Box testing results, all testing scenarios were successfully executed, indicating that the developed application functioned properly without system errors.

Furthermore, the developed system provides a computerized approach for introducing geometric shapes and has the potential to support a more engaging learning process for children. The application of the Viola–Jones method in this study shows that object detection techniques can be utilized as an alternative educational medium for shape recognition and identification.

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