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Hand-Drawn Electronic Component Recognition Using ORB

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Abstract

There is growth in interest to build a system that can recognize freely drawn symbols. In past two years, the situation in the world has become more difficult, almost all the work in their organizations has been digitalized. However, many challenges remain in terms of the recognition accuracy of different drawing styles. To address these challenges, a new approach is proposed to classify and predict the hand-drawn component. In this work Computer Vision approach using the ORB algorithm is used to recognize and predict the component. The drawing tools that are being used need to be upgraded in order to have a better learning experience in order to recognize the symbol that is drawn and directly convert it into digitized form. As it is very difficult to write it on an online platform every time this method would be very useful. Here 15 different electronic components are considered with three different orientations. In this approach, GUI is used to draw the symbol which is easy instead of picking and placing. This input-drawn image is given to the model developed using the CV algorithm, where the input image gets compared with the database image, according to ORB using the FAST method key points are generated for both images. Using a Brute force matcher both images get matched depending on the number of matched features, and the output image gets predicted. The results of the ORB and SIFT CV algorithms are analyzed and compared.

Keywords: Computer vision;electronic component;symbol; sift; orb;key point matching;

1. Introduction

Diagrams are an essential means of capturing and communicating information in different domains. They can also be a valuable part that helps us in exploring ideas and solutions in an informal environment. Communicating through free hand-drawn sketches is more catchy when it is drawn. As there is a rising in going for digital devices like Tablet PCs. There is expanding curiosity in interpreting hand-drawn images [1]. The education domain after an epidemic has moved from offline to teaching online mode. As a result, many faced issues in handling classes in online mode. Especially the content that needs to be explained by drawing had been an issue faced by viewers.

The drawing tools that are being used need to be upgraded in order to have a better learning experience in order to recognize the symbol that is drawn and directly convert it into digitized form. As it is very difficult to write it on an

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online platform every time this method would be very useful [2]. Drawing Circuit symbols have an eminent role in the Electronics and Electrical field of study. These fields of engineers draw circuit diagrams in two different ways. First way is to use paper and pen, and the second method is to use multiple simulation tools that are available[2]. Hence, the automatic recognition of the electronic component symbol is proposed in the work. The issue is, it is very easy for humans to recognize and recall but it is not the same case with computers. The ideas behind the attempt to bridge part of gap between how people manually express an idea and how the computer interprets it.

This paper presents using a Computer Vision algorithm to recognize and predict hand-drawn symbols. By using ORB algorithm which is an efficient alternative to SIFT for the detection and prediction of a component. Custom hand datasets were prepared for considered symbols. The symbols of electronic components that were considered are Inductor, Variable Capacitor, Varactor, Fuse, NAND, Op-Amp, FET, Battery, LED, Voltage control source. In section 3 related works are discussed, where the comparison and analysis made by different authors have been also discussed.

The Proposed work which includes the methodology behind the work with the used algorithm and block diagram, the flow chart of the algorithm, and the proposed work in the paper are discussed in section 4. In section 5, the implementation and results of performed work is mentioned along with performance analysis and comparison of CV algorithms. At the end, the studies have been concluded with the conclusion and future enhancement in section 6 and 7.

2. Purpose/Objective

The idea of the proposed work is to recognize the hand drawn electronic component symbol using ORB. Electronic and logic circuit diagrams is one of the earliest application domains that focused their attention on graphical symbol recognition. Readily available tools in the market are really expensive and few of them are not compatible. Design of such tools at the rear end has many complications such as training, and testing and this process is even time and storage-consuming To reduce the complexity of these methods, the proposed method is developed to recognize the electronic component symbols irrespective of orientations without any training or testing.

3. Related Works

Paper[1] proposed by Alikapati Keerthi Priya et al., has implemented Engineering symbol categorization and identification online using artificial intelligence is carried out. To categorize and digitize the hand-drawn electronic components, a deep learning-based convolutional neural network with a VGG16 architecture is presented. They have considered 15 symbols each of 1100 symbols. The accuracy is calculated after training and testing the specially created dataset. Using CNN first the symbol recognition task is performed where it classifies and recognizes it correctly. Additionally, they had the chance to reconstruct the entire circuit using the symbols that were drawn in the circuit. The recall precision and f1-score were 99% and with validation accuracy 99.2%. The training model's future development will concentrate on adding additional parts, maybe in all directions, as well as more features, to create a robust tool in every practical sense. The notion of technologies, approaches, and algorithms proposed by many writers in their publications is detailed in paper [2], a survey based on hand-drawn symbol classification and recognition. This paper also discussed the different deep deep-learning due and its results. Paper [3] by Manjunath Angadi et al., has implemented the handwritten circuit schematic detection and simulation is done using a computer vision approach. Then they used a classifier called SVM to recognize and classify the shapes based on extracted features. They found that implemented work found to be less complex and faster detection and will find applications in large application areas. Paper[4] analyzed that ORB as an alternative for SIFT Algorithm. The alternative method for this approach includes ORB algorithm with FAST key point detector and BRIEF descriptor because they have good performance over other related algorithms. In this paper ORB and SIFT algorithm are performed over 2 set of data one with indoor set of textured image and other with outdoor scene. ORB outperforms SIFT over outdoor dataset and same with indoor set. Issue found in this algorithm include scale invariance of key point. Future work will focus on GPU/SSE optimization, which could change the scale's order of magnitude. In their paper[5], Günay et al. advocated employing the quick R-CNN method rather than convolutional methods to detect circuit components on hand-drawn circuit images. They have used four different components' voltage source, resistor, inductor and capacitor. The model loss was minimum of 0.048 where this showed that model had high accuracy rate in real time detection. Their future

enhancement focuses on detection of other different passive circuit components. Paper [6] proposed an algorithm to recognize the handwritten digit recognition. For the goal of handwritten digit recognition, they have extensively compared several machine learning and deep learning methods. The algorithms that they have compared are Support Vector machine, Multi Layered Perception and CNN. By comparing the models' accuracy during training and testing, it was discovered that CNN achieved a higher accuracy of 99.31%, leading to the conclusion that CNN is the best option for all types of prediction issues. Their planned improvements will focus on using hybrid or denser algorithms than the ones they currently use to handle a variety of recognition-related problems. A new symbol classifier that is computationally efficient is proposed which includes in three domains like in identifying handwritten digits, electronic symbols, power point shapes.[7]. The paper represents a method of extracting features from an image and matching them with other view of object or scene. It includes extraction of features for object recognition.[8]. Key point detection, description and matching methods are performed over different dataset for evolution in SIFT, SURF, ORB and BRISK algorithms.[9]. Experimental results show improved orb algorithm is more accurate and faster.[10]. Significance of Local invariant features are proved in the literature. Combination of two types of features to get salient key point which are highly distinctive and improves matching performance.[11]. Hand drawn component recognition using CNN and soft max classifier is suggested their recognition method has 95% accuracy in identifying rotated electronic component.[12]. Image mining mainly deals with extraction of embedded details pattern and their relationship in images scale and rotation invariant features namely key points can be extracted from the image classification and mining. Then key point from test image is extracted and classified by KNN Classifier then the set of key points are matched for SIFT based object detection and tagging.[13]. It makes changes to electronic documents using speech and gestures as inputs, as indicated. [14]. Mathematical expressions and flowchart id structures could be understood and differentiated by handwritten graphic recognition. [15]. There is a sophisticated segmentation method to identify online complex freehand sketching techniques. [16]. Hand drawn circuit diagram recognition achieved 90% success rate in classification using 90 scanned images of circuit using KNN method.[17]. Few changes in faster R-CNN method made recognition of symbols on handwritten graphics and mathematical expressions.[18]. Key point matching and comparisons between stereo pairs of images are used to detect the distance between cars in order to prevent accidents.[19]. The various ORB enhanced algorithms are discussed, and various feature matching performance indices are run.[20]. In all the works related to hand drawn symbol recognition they have limited the number of components and prediction accuracy is very less. In this work the number of components used is more and instead of going for training of model and predicting the component here an efficient method to predict component is performed. From the references stated ORB is one of the better and efficient image matching algorithms.

4. Proposed Methodology

This division discusses Computer vision and its algorithms, block diagram and working of algorithm identified for the proposed methodology that is used to recognize the hand drawn electronic symbols.

4.1. Computer Vision

Object recognition is the most important area in domain of Image Processing and CV. The field of CV focuses on using computers to extract in-depth knowledge from pictures or videos. In order to produce numerical information, this mostly entails the tasks of collecting, analysing, and comprehending images as well as extracting high-dimensional data from the real world. Few related fields with respect to CV are solid state physics, robotic navigation, signal processing etc. In CV fast and robust image matching is the most significant task. In Image matching there are few algorithms SIFT, SURF, ORB. In this paper the algorithms considered are SIFT and ORB.

4.2. Database

Database usually consists of considered components image in which input image compares. As here orientations are considered for the component, the oriented components will be considered. The resolution size of database is 370*400. The image is in .jpg format. The considered component orientations are 90˚,45˚,0˚. The images in database

should have less size because less size does not take more time to load. Table 1 shows the number of components considered for the work.

Table 1. Name of the electronic symbol components used.

Name of the Components		
Inductor	Operational Amplifier	Fuse
Variable Capacitor	NAND	NMOS
Varactor	Voltage Control Source	FET

4.3. CV algorithm

Preferred CV algorithms used for feature matching of images are been considered and discussed in the section which includes block diagram and explanation of SIFT algorithm and ORB algorithm.

SIFT(Scale invariant Feature transform): It was proposed by Lowe which helps for matching local features in the image. This algorithm has four basic steps as shown in fig.1(a). First is to estimate scale space extrema using the difference of gaussian (DOG) which makes sure that features are scale independent and the most distinct features by ignoring the noise must be identified. Gaussian Blurring is done to reduce the noise. A collection of images with various scales called scale space is created from one image. Secondly, key points are localized by eliminating the lower contrast points, by finding local maxima and local minima, it removes the low contrast key points. Thirdly, a key point orientation assignment is done which assigns orientation and magnitude so that images are invariant to rotation and then it creates the histogram for both magnitude and orientation. Lastly, a neighbourhood image will be having descriptor for every key point giving magnitude and orientation.

Feature matching is performed using a brute force matcher. It's a descriptor matcher that compares two sets of key point descriptors and generates matches. It uses distance calculation to match the descriptor of one feature from the first set with every other feature in the second set, which is performed by hamming distance measurement.

ORB: It is called as ORB because it is based on the recently created BRIEF descriptor and FAST key point detector (Oriented FAST and Rotated Brief). Both of these methods are efficient due to their affordability and high quality. As shown in fig.1(b). Initially to get the key points for the input image it uses the FAST method and multiscale Image pyramid. Using this key point is detected. It is very efficient as it finds reasonable corner key points. After locating Key points at each level, it assigns orientation to every key point by considering intensity a feature descriptor called BRIEF employs straightforward binary comparisons between pixels in a smoothed picture. In order to represent an object, BRIEF takes all the important locations identified by FAST and transforms them into binary feature vectors. These features are referred to as binary descriptors that contain 0 and 1. Using a Brute force matcher, feature matching will be done.[9]

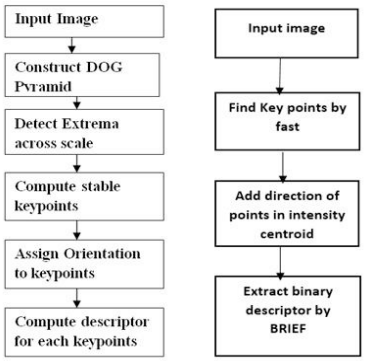

Fig. 1.(a) Block diagram of SIFT algorithm;(b) Block diagram of ORB Algorithm.

4.4. Block Diagram

The approach for object recognition includes the computer vision algorithm, which matches the features based on the key points generated on the image. Computer Vision is under the field of Artificial Intelligence (AI), it mainly focuses on creating digital systems which is able to perform, process either images or video in same way the humans do. Technically, CV in machine learning will make an attempt to extract the visual information and convert results through the algorithms.

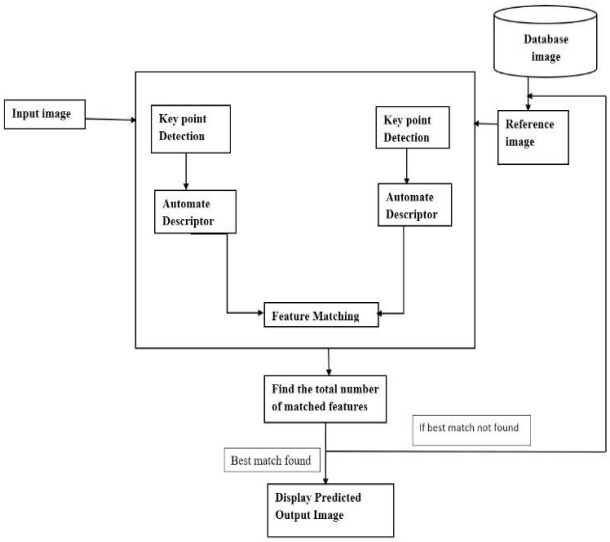

Fig. 2.Block diagram of the proposed work.

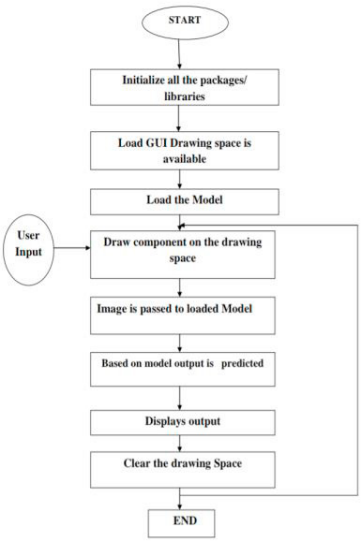

Fig. 3. Flow chart of the proposed work

Fig. 2 represents block diagram of the proposed work. Initially, raw image is given as an input image to the model and for that image key points are detected and allocated using FAST method in ORB. An image from database is taken as reference image and for that image also, key points will be detected. Once the key points are allocated, Binary descriptors are assigned using BRIEF because it is variant to rotation. From those two images, using specific Feature Matcher total number of matched features will be extracted and total features will be compared. Certain threshold value is considered. Depending on the total number of features the best match will be found. Based on the best match the output image will be predicted else it returns to the database image and then repeats all the steps.

The proposed work is able to achieve better results in object detection. The work mainly concentrates on recognition of the hand drawn electronic components, drawn in different orientations.

4.5. Proposed Method Flow Chart

Fig. 3 explains the flow chart of the proposed work. The model is loaded and packages are initialised at the start of the proposed procedure. This will load the GUI drawing space which is created. On GUI canvas the input image will be drawn which is saved and this saved image is given as an input to model, that is built using algorithm. The key points will be allocated on the input image and compared database image. This will be done by CV2.ORB_CREATE(). Once the key points are allocated the key points will be matched with CV2.BF_FeatureMatcher() and matching lines will draw. Based on the total number of matched features the component output will be predicted and it displays it as output. Once the output is displayed the drawing space can be cleared and can redraw another image.

5. Implementation and Result

The implementation includes giving the input image to the model that is developed using orb algorithm. The environment setup used for the simulation is Pycharm community edition 2021.1.2. To proceed Installing the OpenCV library is a good idea since it is a library of programming functions with a focus on real-time computer vision. Using

this package ORB algorithm can be created where the input image will be given to model. Input image compares with the database and keypoint allocation will be done,further those keypoints will be matched and than depending on the number of features the output component will be predicted.

The implemented results are shown in the below sections. In this work to give the input whiteboard is considered which is of size 370*400. Input Image is given to the model that is constructed using CV algorithm where it compares with the database and then predicts the output. From the point of ease, only three different orientations are considered for analysis.

5.1 Performance Evaluation

The performance evaluation is shown in table2 which compares with size of dataset, system configuration, and computation speed for VGG16 , ORB and SIFT algorithm. In paper[1] it is shown that the component prediction is done using DL based VGG16 architecture model based on their paper the performance is done

Table.2.Performance Comparison

PARAMETER	VGG16	ORB	SIFT
Size of Dataset	Large datasets are required to train and test	Small size of datasets	Small size of datasets
System Configuration	Memory required is high. High end system, GPU supported systems are highly compatible. Cost is high	Memory required is less. Windows system are sufficient. Less Cost	Memory required is less. Window system are sufficient. Less Cost
Computation Speed	It takes much time to load the datasets.	As datasets are less to compute speed is very high	As datasets are less to compute speed is high
Training Required	Yes	No	No

By comparing the above parameters it can be clearly observed that CV algorithms are more efficient when compared with different parameters.

5.2. Comparison of ORB and SIFT

Comparison of ORB and sift when compared with a number of matched features is plotted in below fig. 4. In this the input image is considered with angle 90˚, and it is constant, and it is compared with 0˚,45˚,90˚ images in the database for both ORB and SIFT. The input image that is considered to perform is Inductor which is 90˚ which is considered as α and it is compared with database image, which is considered as β1,β2,β3 (90,45 and 0).

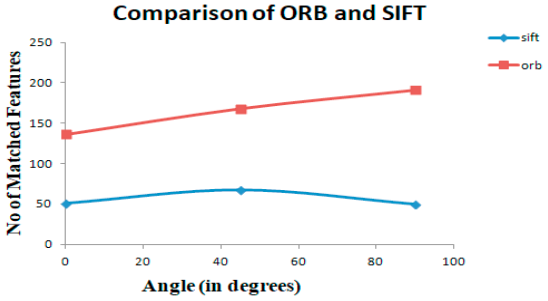

Fig. 4. Comparison of ORB and SIFT

In ORB when input image is matched with 0˚ the features obtained are less, whereas when it is at 45˚ it is average and when it is at 90˚ the total number of matches is more. In SIFT when 0˚ image is matched with 0˚ the matched features obtained is average and when 45˚ is compared it is more and when 90˚it is less. By this, we can conclude that ORB performs more efficiently and accurately when orientations are considered when compared to SIFT.

Table 3: Analysis of Component

Angle(in degrees)	Total number of matched features			Angle of Predicted Image
Input Image	Database Image	Inductor	Voltage Control Source	
90˚	90˚	487	385	90˚
	45˚	133	133	
	0˚	117	106	
45˚	90˚	133	131	45˚
	45˚	500	497	
	0˚	137	133	
0˚	90˚	117	106	0˚
	45˚	137	131	
	0˚	500	372	

Table 3 represents the analysis performed while checking the input image by giving it with different angle. Consider (α) as Input Image angle and Database angle as (β).
Let β1 be the database image of angle 90˚,β2 be the database image of angle 45˚ and β3 be the database image of an angle 0˚.

- If,$\alpha = 90^\circ$, $then\ \alpha - \beta 1 = 90^\circ - 90^\circ = 0^\circ$ where the angle difference is 0˚ hence, that image will be having maximum number of matched features.
- If $\alpha = 90^\circ$, then $\alpha - \beta 2 = 90^\circ - 45^\circ = 45^\circ$where the angle difference is 45˚hence that image will be having less than maximum number of matched features.
- If $\alpha = 90^\circ$,then $\alpha - \beta 3 = 90^\circ - 0^\circ = 90^\circ$ where the angle difference is 90˚ hence that image will be having minimum number of matched features.
- If $\alpha = 45^\circ$,then $\alpha - \beta 1 = 45^\circ - 90^\circ = 45^\circ$ where the angle difference is 45˚ (anti) hence that image will be having minimum number of features.
- If $\alpha = 45^\circ$,then $\alpha - \beta 2 = 45^\circ - 45^\circ = 0^\circ$ where the angle difference is 0˚ hence that image will be having maximum number of matched features.
- If $\alpha = 45^\circ$,then $\alpha - \beta 3 = 45^\circ - 0^\circ = 45^\circ$ where the angle difference is 45˚(clk)hence that image will be having less than maximum number of matched features.
- If $\alpha = 0^\circ$, then $\alpha - \beta 1 = 0^\circ - 90^\circ = 90^\circ$ where the angle difference is 90˚ hence that image will be having minimum number of matched features.
- If $\alpha = 0^\circ$, then $\alpha - \beta 2 = 0^\circ - 45^\circ = 45^\circ$ where the angle difference is 45˚hence that image will be having less than maximum number of matched features.
- If $\alpha = 0^\circ$,then $\alpha - \beta 3 = 0^\circ - 0^\circ = 0^\circ$ where the angle difference is 0˚ hence that image will be having maximum number of matched features.

Find $\alpha - \beta 1, \alpha - \beta 2, \alpha - \beta 3$;

$$\alpha - \beta 1 = (0^\circ)(no.of\ matched\ features\ 1) \quad (1)$$

$$\alpha - \beta 2 = (45)(no.of\ matched\ features\ 2) \quad (2)$$

$$\alpha - \beta 3 = (90)(no.of\ matched\ features\ 3) \quad (3)$$

$$X = Max((no.Of\ matched\ features 1), (no.Of\ matched\ features\ 2), (no.Of\ matched\ features\ 3)) \quad (4)$$

Database Image of higher no. Of matched features will be predicted.

From the analysis mentioned in the table 4 it can be concluded that ORB algorithm is very much better in allocation of key points than sift algorithm, as here in the proposed work the hand drawn component need to have more number of key points for feature matching. Only then it can be able to predict output. Therefore, ORB is more efficient and

convenient algorithm compared to SIFT.

Table .4. Analysis of Key Points generated by SIFT and ORB algorithm

Component Name	SIFT (No. of Keypoints)		ORB (No. of Key points)	
	Input Image	Database image	Input Image	Database Image
Inductor	95	88	352	375
Variable Capacitor	72	74	358	364
Operational-amplifier	42	40	175	206

5.3 . Symbol Recognition

The proposed work is discussed with an example of considered components, where different hand written component drawn on the canvas, given as an input image to the algorithm and their predicted images are shown in the respective figures.

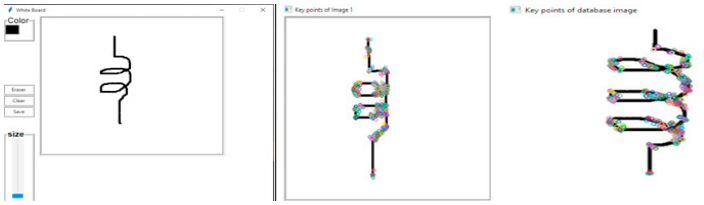

Fig. 5. (a)input image draw; (b)Keypoints of input image; (c)keypoints of database image.

Input image of considered component inductor is drawn through GUI which is of size 370*400 (width*height) canvas shown in Fig 5a, where the drawn image will be saved in .jpg format and is given to the model. Allocation of key points of input image(5b), allocation of keypoints of database image(5c).Keypoint matching is done in(6a). The predicted output is shown in fig (6b).

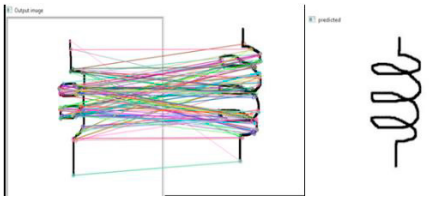

Fig. 6. (a)keypoint matching; (b)Predicted image.

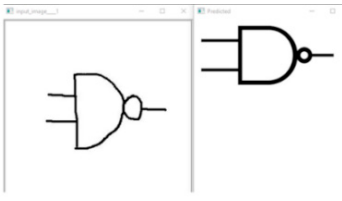

Fig. 7. Nand (a)Input;(b) Output.

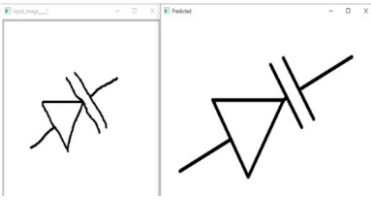

Fig. 8. Varactor (a)Input; (b)Output.

5.4. Different Component are not Recognized

In fig.9a it can be seen that when inductor is matched with fuse, then by obtained total number of features it recognizes as different Component. In fig 9b shows that battery and fet is not matching.

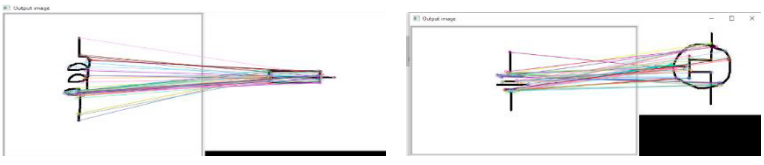

Fig. 9(a) Two different component not matching; (b) Two different components are not matching.

5.5 Analysis of Component with Respect to their Orientation

In the section 5.5 analysis performed in the work are discussed with different orientation of database image compared with same orientation of input image is shown in Fig. 10(a),(b),(c).

Fig. 10.(a)both images are 0º;(b)input image is 0º and database is 45º;(c)input is 0º and database is 90º.

6. Conclusion

As the education domain is leading towards virtual mode there is a vast scope in going towards an online education system. The paper represents an experiment to recognize free hand-drawn components using a computer vision algorithm. Even though the input image is drawn in different styles the output image is predicted. The comparison with three different orientations of the symbol along with multiple input images has been performed. The free hand-drawn symbol gets displayed in digitized form. This solution will help in updating the virtual mode of education. Instead of using additional hardware like a digital pen, this proposed work will make the requirement easier. As there is a lot of scope to the online education system which is being conducted all over the world in a blended way, this will play an important role in future education systems. In this work, the comparison of both the SIFT and ORB algorithms is done, and have concluded that ORB performs better and faster than SIFT in recognizing the component.

7. Future Enhancement

The future development of applications based on algorithms in Computer Vision is boundless. In future work, different denser algorithms can be used to achieve solutions to many problems. Research may be expanded to a number of other educational fields as well as virtual gatherings, book releases, etc. Much more different symbols can be considered by including all different orientations with different variables. By developing it as a tool it can be integrated with different online platforms.

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