

Raju Surampudi Bapi  
Koppula Srinivas Rao  
Munaga V. N. K. Prasad *Editors*

# First International Conference on Artificial Intelligence and Cognitive Computing

AICC 2018

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Editors

# First International Conference on Artificial Intelligence and Cognitive Computing

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 Springer

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# Preface

The first international conference on Artificial Intelligence and Cognitive Computing (AICC 2018) was successfully organized by MLR Institute of Technology, Hyderabad, India, from 2 to 3 February 2018. The objective of this international conference was to provide a platform for academicians, researchers, scientists, professionals and students to share their knowledge and expertise in the fields of artificial intelligence, soft computing, evolutionary algorithms, swarm intelligence, Internet of things, machine learning, etc., to address various issues to increase awareness of technological innovations and to identify challenges and opportunities to promote the development of multidisciplinary problem-solving techniques and applications. Research submissions in various advanced technology areas were received, and after a rigorous peer review process with the help of technical programme committee members, elite quality papers were accepted. The conference featured nine special sessions on various cutting-edge technologies which were chaired by eminent professors. Many distinguished researchers like Prof. D. K. Subramaniam; Tandava Popuri, Director, R&D Dell systems; Dr. Bapi Raju Surampudi; Dr. Suresh Chandra Satapathy; Dr. S. Rakesh; Dr. K. Venugopal; Mr. Nagarjun Malladi; Mr. Sriharsh Bhyravajjula, India, attended the conference. Plenary talk was given by Abhimanyu Aryan on artificial intelligence and virtual reality.

Our sincere thanks to all special session chairs Dr. N. Sandhya, VNRVJIET, Hyderabad; Dr. DVLN Somayajulu, NIT Warangal; Dr. Y. Rama Devi, CBIT, Hyderabad; Dr. B. Rama Abbidi, Kakatiya University, Warangal; and distinguished reviewers for their timely technical support. We would like to extend our special thanks to very competitive team members for successfully organizing the event.

Finally, we thank Dr. Suresh Chandra Satapathy, PVPSIT, Vijayawada, for his complete guidance being Publication Chair in bringing out a good volume in Springer AISC series.

Hyderabad, India

Dr. Koppula Srinivas Rao  
Dr. Raju Surampudi Bapi  
Dr. Munaga V. N. K. Prasad

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# Automatic Retail Product Image Enhancement and Background Removal



Rajkumar Joseph, N. T. Naresh Babu, Ratan S. Murali  
and Venugopal Gundimedda

**Abstract** Retailers need good-quality product images with clear background on their Web sites. Most of these product images captured have diverse backgrounds, posing a challenge to separate the foreground from the background along with the enhancement of the product image. Currently, most of these activities are done manually. Our study proposes a computer vision (CV)- and machine learning (ML)-based approach to separate foreground (FG) and background (BG) from retail product images and enhance them. This automated process of BG/FG extraction involves two steps. A neural network (NN) classifier to identify if the BG has a monocolour gradient or not, followed by the separation of FG from BG and enhancement applied on the FG from the input image. Our results show 91% accuracy for BG/FG extraction and identifying the product region of interest (ROI).

**Keywords** Background removal · Image matting · Image enhancement  
Machine learning

---

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## 1 Introduction

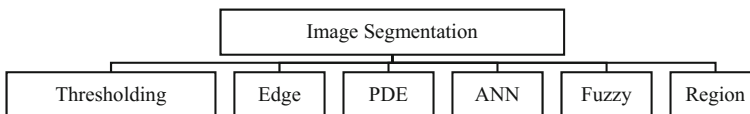
Retail product images generally are shot using various cameras with a contrasting background. In most of the cases, we have products being shot on a white background. White is generally not pure white when it is photographed and thus introduces various noises and some shades generally having gradient of gray and white whose variation changes depending on illumination and exposure settings of the camera. Generally, most algorithms require manual intervention to provide indicative markers to identify foreground and background regions. We propose a system that automatically removes background having monochrome gradients (not considering natural scene backgrounds) and enhances the foreground from input images. The proposed system has been optimized to work with retail product photography images only, images have monochrome-based background, and background color should be brighter than foreground object and with no outlier objects presented in camera view.

## 2 Related Work

The objective of background removal is to extract useful region/region of interest (ROI) from images without human assistance. Most of the BG vs FG separation techniques rely on color to determine the alpha matte and also consider few low-level features. Others like sampling-based methods rely on extracting colors by sampling the known FG and BG followed by a computation to determine the best FG/BG combination. Segmenting ROIs is a difficult problem in image processing, and it has been an active area of research for several decades. Different image segmentation techniques are shown in Fig. 1.

The thresholding methods like global, local, and adaptive techniques are used to extract ROIs [1–3]. The advantage of thresholding technique is to make threshold calculations faster and effective. Global algorithm is well suited only for the images with equal intensities. This method does not work well with variable illumination. The drawback of adaptive thresholding is computationally expensive, and therefore, it is not suitable for real-time applications. Zhu [4] proposed a new threshold-based edge detection and image segmentation algorithm. The threshold is computed for each pixel in the image on the basis of its neighboring pixels.

Yucheng [5] proposed a new fuzzy morphological-based fusion image segmentation algorithm. The algorithm uses morphological opening and closing operations to



**Fig. 1** Image segmentation techniques

smoothen the image and then perform the gradient operations on the resultant image [6, 7]. Khokher [8] presented a new method of image segmentation using fuzzy rule-based system and graph cuts [9]. The above fuzzy-based clustering technique has drawbacks, and it is sensitive to noise and computationally expensive, initialization condition of cluster number and cluster center. Also, the technique does not work well with non-globular clusters, and determination of fuzzy membership is not very easy.

Image matting is widely used to segment the target image from image/video. Popular matting techniques are blue screen matting, Bayesian matting, closed-form matting, geodesic matting, easy matting, graph cut, and deep matting. The different matting techniques are covered in [10–16]. In [13], authors used the geodesic framework to classify the pixels between foreground and background. However, this framework requires two manual inputs (select two lines, one on foreground region and other one on background region) to do automatic segmentation. This method exploited weights in the geodesic computation that depends on the pixel value distributions. The algorithm works best when these distributions do not significantly overlap. Human intervention is required to select foreground and background to achieve better accuracy. Also, it fails with transparent foreground images. Recently, various deep learning techniques have been proposed for image matting [15–18]. This area is still an active area of research due to complex nature of the FG/BG images.

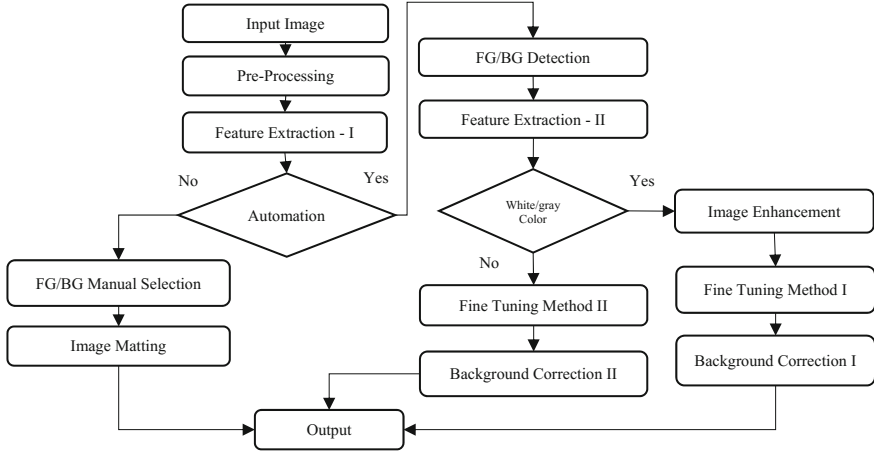
### 3 The Proposed Work

The proposed system is designed to remove background and enhance the foreground object. The proposed framework is shown in Fig. 2.

To validate our prerequisite assumptions, the input product image is sent to automation classifier which identifies whether we have a monochrome background. Once we conclude that the input image has a monochrome background, we do a white/gray color classification check. Most of the retail product images are captured with white/gray background. For white/gray background images, fine-tuning method I is used. This method also works for non-contrasting BG/FG colors. For monochrome gradient (nonwhite/gray) background images with contrasting BG/FG colors, fine-tuning method II is used. If automation classifier is “No,” manual selection is suggested.

#### 3.1 Preprocessing

The input image is captured from a camera device. Convert RGB image to  $L^*a^*b$ . Concentrate on “L” channel to further proceed. Apply histogram to “L-Channel.”



**Fig. 2** Framework for the proposed system

Find highlighters' side peak. Stretch the image from 2% of highlighter. The stretched image ( $L^*a^*b$ ) is converted back to RGB for further process.

### 3.2 Feature Extraction I and II

In this proposed system, we assume our scope has monochrome gradient background. So to identify monochrome background or not (texture pattern or natural scene, etc.), we introduced a classifier. Once classifier satisfies scope, then our proposed system will remove background automatically, else it will go to manual selection-based background removal. Histogram, vertical projection profile (VPP), and horizontal projection profile (HPP) are used as the features for the feature vector of the classifier, and the features are derived from grayscale image. VPP and HPP are calculated using Eq. (1). Number of histogram bins are 32, and they are normalized with respect to total numbers of pixels. Similarly, horizontal and vertical projection bins are 32, and they are normalized with respect to height/width and n-bit gray scale; it is derived from Eqs. (2) and (3). Therefore, total feature vector size is 96 ( $32 \times 3$ ).

$$VPP = \sum_{l \leq x \leq m} f(x, y); \quad HPP = \sum_{l \leq y \leq n} f(x, y) \quad (1)$$

$$NVPP = VPP / (\text{Height} * 2^{N_{\text{bit grayscale}}}) \quad (2)$$

$$NHPP = HPP / (\text{Width} * 2^{N_{\text{bit grayscale}}}) \quad (3)$$

**Table 1** Parameter for MLP

Parameters	Number of perceptrons	Activation function	Training algorithm	No of epochs	Learning rate
Value	64	tanh	Levenberg–Marquardt, Back-propagation	100	0.1

where  $f(x, y)$ —input image,  $m$ /height—no of rows in the image,  $n$ /width—no of columns in the image, NVPP—normalized vertical projection profile, NHPP—normalized horizontal projection profile.

### 3.3 Classifier

Two classifiers are used in the proposed system. One is automation classifier, which is used to identify whether monochrome gradient background is present or not in the given input image. Another one is used to identify whether white/gray background is present or not in the given input image. We used multilayer perceptron (MLP), a type of neural network (NN) [19, 20] for classifications. Parameter for MLP is shown in Table 1.

### 3.4 Foreground Detection

Illumination correction is done using morphological operation. Convert input image into grayscale image, and apply morphological operation “open”; it is equivalent to opening ( $I_g$ ). The illumination-corrected image is derived from Eq. (4). Diamond-shaped structuring element is used.

$$ICI = I_g - \text{Opening}(I_g) \quad (4)$$

where ICI—illumination-corrected image and  $I_g$ —grayscale image. Normalized vertical projection profile (NVPP) and normalized horizontal projection profile (NHPP) are calculated on illumination-corrected image. There will be significant change in intensity toward background to foreground. So differentiation is applied to identify starting point of foreground location. To suppress noise, normalization with respect to mean and moving average filter is used.

$$VPP = \left| \frac{\partial NVPP}{\partial X} \right|; \quad HPP = \left| \frac{\partial NHPP}{\partial y} \right| \quad (5)$$

$$NVPP = VPP/\mu_{VP}; \quad NHPP = HPP/\mu_{HP} \quad (6)$$

$$V(x) = \begin{cases} 1 & \text{if NVPP} \geq k * \sigma_{\text{NVPP}} \\ 0 & \text{if NVPP} < k * \sigma_{\text{NVPP}} \end{cases} \quad (7)$$

$$S_x = \min \arg(V(x) = 1); \quad E_x = \min \arg(V(x) = 1) \quad (8)$$

$$H(y) = \begin{cases} 1 & \text{if NHP} \geq k * \sigma_{\text{NHPP}} \\ 0 & \text{if NHP} < k * \sigma_{\text{NHPP}} \end{cases} \quad (9)$$

$$S_y = \min \arg(H(y) = 1); \quad E_y = \min \arg(H(y) = 1) \quad (10)$$

where  $S_x, E_x, S_y, E_y$  are the rectangle coordinates of ROI region.

### 3.5 Image Enhancement

Image enhancement is done only for white/gray background images using exposure setting. Exposure settings are derived mathematically using following Eqs. (11)–(17) and background RGB image has to convert into gray to apply histogram. In histogram graph, the darkest tone available is zero, and it is shown at the left-hand side of the graph. The lightest, whitest tone achievable is 255 on the scale, and it is shown on the extreme right of the graph. To get the best tonal range, and to avoid problems with underexposed shadows or overexposed highlights, the histogram should be vaguely bell-shaped. So, the histogram graph should move toward right-hand extremes with respect to  $-2*(\sigma)$  from the peak histogram count.

$$\max H = \arg \max_{0 \leq i \leq n} (H_g(i)); \quad \lim_{i \rightarrow \text{optimal } H_g} H_g = 2 * \sigma_{H_g} \quad (11)$$

$$H_{\text{optimal}} = \begin{cases} \min \arg(\text{Optimal } H_g) & \text{if } H_g(\max H) \geq 2 * \sigma_{H_g} \\ \max H & \text{else} \end{cases} \quad (12)$$

$$E = 2^{n_{\text{bit}}} / H_{\text{optimal}} \quad (13)$$

$$H = H_g * E \quad (14)$$

$$MI_g = H(I_g) \quad (15)$$

$$H_R = H_R * E; H_G = H_G * E; H_B = H_B * E; \quad (16)$$

$$I_R = H_R(I_R); I_G = H_G(I_G); I_B = H_B(I_B) \quad (17)$$

where  $\max H$ —location of peak histogram count,  $H_{\text{optimal}}$ —optimal location for image enhancement,  $E$ —exposure value of the given image,  $MI_g$ —modified grayscale image with respect to histogram stretched value,  $I_R, I_G, I_B$ —modified image, combination of histogram image  $H_R, H_G, H_B$  to red, green, blue channels, respectively.

### 3.6 Foreground Fine-Tuning Method I

This method is for white/gray gradient background images. Sometimes, product photographs are taken without contrasting color between background and foreground and some of input images do not have uniform background, and it is corrupted by noise, illumination, shadow lines, etc. So we used color and edge information combing together to fine-tune foreground detection to achieve better background subtraction [21]. Fine-tuning is done using sensitivity factor (SF). SF is purely based on probability-based metric foreground. Apply histogram to foreground image and background image. Here, the total number of histogram bins is 256. The SF is calculated using Eq. (20). From Eq. (21),  $FG_{\text{mask}0}$  is calculated. Local standard deviation  $\overline{\sigma}_{\text{local}}$  of image is calculated using Eq. (23) with help of Eq. (22),  $FG_{\text{mask}0}$  is calculated from Eq. (24). Sensitivity factor for intensity of color information  $FG_{\text{mask}0}$  and sensitivity factor for local edge information  $\overline{\sigma}_{\text{local}}$  both are fused by weighted average (weights are  $W_1, W_2$ ). The  $FG_{\text{mask}}$  is calculated from Eq. (25).  $th_{\text{SF}}$ —threshold value for foreground region.

$$P_{\text{FG}}(i) = \frac{\sum H_{\text{FG}}(i)}{\sum H_{\text{FG}}(i) + \sum H_{\text{BG}}(i)} \quad (18)$$

$$P_{\text{BG}}(i) = \frac{\sum H_{\text{BG}}(i)}{\sum H_{\text{BG}}(i) + \sum H_{\text{FG}}(i)} \quad (19)$$

$$\text{SF} = P_{\text{FG}}/P_{\text{BG}} \quad (20)$$

$$FG_{\text{mask}0} = \begin{cases} 1 & \text{if } \text{SF} \geq th_{\text{SF}} \\ \frac{\text{SF}}{th_{\text{SF}}} & \text{if } \text{SF} < th_{\text{SF}} \end{cases} \quad (21)$$

$$\bar{X}(i, j) = \frac{1}{(2n+1) * (2m+1)} \sum_{i-n}^{i+n} \sum_{j-m}^{j+m} I_g(i, j) \quad (22)$$

$$\overline{\sigma}_{\text{local}}(i, j) = \sqrt{\frac{1}{(2n+1) * (2m+1)} \sum_{i-n}^{i+n} \sum_{j-m}^{j+m} [I_g(i, j) - \bar{X}(i, j)]^2} \quad (23)$$

$$FG_{\text{mask}1} = \begin{cases} 1 & \text{if } \overline{\sigma}_{\text{local}} \geq th_{\sigma} \\ 0 & \text{if } \overline{\sigma}_{\text{local}} < th_{\sigma} \end{cases} \quad (24)$$

$$FG_{\text{mask}} = (W_1 * FG_{\text{mask}0}) + (W_2 * FG_{\text{mask}1}) \quad (25)$$

$$W_1 + W_2 = 1; W_1, W_2 \geq 0; W_1, W_2 \leq 1 \quad (26)$$

### 3.7 Foreground Fine-Tuning Method II

In Sect. (3.6), we proposed foreground fine-tuning method I, which works better for gray/white background. This method will work for any monochrome gradient. We



redefine SF which will play a major role for nonwhite/non-gray background. The multivariate Gaussian distribution for foreground ( $G_{FG}$ ) and multivariate Gaussian distribution for background ( $G_{BG}$ ) are derived from Eqs. (27) to (28), respectively. SF is calculated from Eq. (29), and it is known as foreground mask ( $FG_{mask}$ ).

$$G_{FG} = \frac{1}{\sqrt{(2\pi)^k |\Sigma|}} \exp^{-\frac{1}{2}(X-\mu_{FG})^T \Sigma^{-1}(X-\mu_{FG})} \quad (27)$$

$$G_{BG} = \frac{1}{\sqrt{(2\pi)^k |\Sigma|}} \exp^{-\frac{1}{2}(X-\mu_{BG})^T \Sigma^{-1}(X-\mu_{BG})} \quad (28)$$

$$SF = \begin{cases} 1 & \text{if } I_R \geq \mu_R, I_G \geq \mu_G, I_B \geq \mu_B \\ 1 & \text{if } \frac{G_{FG}}{G_{BG}} \geq d \\ \frac{G_{FG}}{G_{BG} * d} & \text{if } \frac{G_{FG}}{G_{BG}} < d \end{cases} \quad (29)$$

$$FG_{mask} = SF \quad (30)$$

where  $\Sigma$ —covariance matrix,  $\mu_{FG}$ —mean (foreground image),  $\mu_{BG}$ —mean (background image),  $d$ —threshold,  $I_R, I_G, I_B$ —image pixel values red, green, blue, respectively.

### 3.8 Background Correction

Background correction is done by increasing brightness on background region only. To achieve this enhancement, separate each color component ( $I_R, I_G, I_B$ ) and do following mathematical operation on foreground masked image ( $FG_{mask}$ ) referring to Eq. (30). The background-corrected image is calculated using Eqs. (31)–(33).

$$\text{Output}_R = I_R + (1 - FG_{mask}) * (2^{n_{bit}} - \mu_{BGR}) \quad (31)$$

$$\text{Output}_G = I_G + (1 - FG_{mask}) * (2^{n_{bit}} - \mu_{BGG}) \quad (32)$$

$$\text{Output}_B = I_B + (1 - FG_{mask}) * (2^{n_{bit}} - \mu_{BGB}) \quad (33)$$

where  $FG_{mask}$ —foreground masked image,  $\mu_{BGR}, \mu_{BGG}, \mu_{BGB}$ —mean of red, green, blue channels to background image, respectively. Thresholding is done to output image to recompute,  $FG_{mask}$  along with surface removal has been done using median filter, morphological to the processed image (output) and the mask have been updated.

$$SFG_{updatedmask} = \begin{cases} 1 & \text{if } \text{Output}_{grayscale} \geq th_{recompute} \\ 0 & \text{if } \text{Output}_{grayscale} < th_{recompute} \end{cases} \quad (34)$$

### 3.9 Image Matting

Moving forward, after identifying foreground detection, image matting technique is applied. We used Bayesian matting. The purpose of matting is to extract foreground objects from background, often for the purpose of compositing with new environments. A foreground object is extracted from the background by estimating the color and opacity, or alpha channel, for the foreground elements at each pixel. The color value can then be expressed by the composition Eq. (35):

$$SC = \alpha F + (1 - \alpha)B \quad (35)$$

where  $F$  and  $B$  are the foreground and background colors, alpha ( $\alpha$ ) is the opacity map, and  $C$  is the resulting color. Therefore, matting can be considered as the inverse process of composition, where we start from a composite image and attempt to extract the foreground and alpha images. This process is typically guided by a user indicating the location of foreground objects.

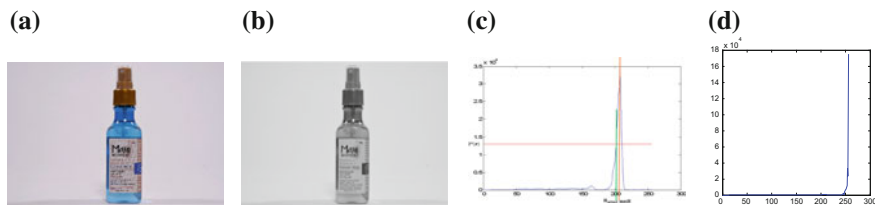
This proposed system implements the technique described in [13], where the matting problem is formulated in Bayesian framework and solved using maximum a posteriori (MAP) optimization. In this approach, we search for the most likely estimates of foreground ( $F$ ), background ( $B$ ), and alpha ( $\alpha$ ) given  $C$ , the observed color. More formally, Eq. (36) is written as

$$\arg \max_{F, B, \alpha} P(F, B, \alpha | C) \quad (36)$$

Applying Bayesian rule, taking the logarithm, and neglecting some terms, now the above equation becomes Eq. (37)

$$\arg \max_{F, B, \alpha} L(C|F, B, \alpha) + L(F) + L(B) \quad (37)$$

where  $L(\bullet)$  denotes the log-probability. Chuang [13] explained model each of these terms by means of Gaussian distributions (isotropic for the first term, and unisotropic for the second and third), reflecting the spatial distribution of foreground and background colors in the image. As their resulting likelihood equation is not quadratic, it is solved using alternating iterations, until convergence. To guide the algorithm, a trimap  $M$  is required to be given by the user. This map indicates the background regions, foreground regions, and unknown regions. The pixels marked as foreground and background are automatically assigned alpha values 1 and 0, respectively, while the unknown pixels are processed based on the foreground and background information as described above.



**Fig. 3** **a** Input image, **b** gray image, **c** histogram plot, **d** histogram exposure up to 2%

**Table 2** Data set for automation classifier

Number of sample for training	208
Number of sample for validation	44
Number of sample for testing	1408

**Table 3** Training for MLP

Actual/prediction	0	1	Precision (%)
0	96	0	100
1	0	112	100
Recall (%)	100	100	
Accuracy (%)	100		

**Table 4** Validation for MLP

Actual/prediction	0	1	Precision (%)
0	20	0	100
1	0	24	100
Recall (%)	100		
Accuracy (%)			100

## 4 Results and Discussion

The product input image has been captured using digital camera. After the conversion of RGB image to gray, apply histogram technique. Figure 3a–d shows input image, grayscale image, and histogram plot and histogram exposure up to 2%, respectively.

Table 2 describes data sets for automation classifiers. Confusion matrix has been given in Tables 3, 4, and 5 for training, validation, and testing, respectively.

Table 6 describes data sets for white/gray background classifiers. Confusion matrix has been given in Tables 7, 8 and 9 for training, validation, and testing, respectively.

Figure 4a shows the initial contour detection done using horizontal and vertical projections. Figure 4b shows results from horizontal and vertical projection techniques.

**Table 5** Testing for MLP

Actual/prediction	0	1	Precision (%)
0	450	3	99.34
1	0	955	100
Recall (%)	100	99.69	
Accuracy (%)	99.79		

**Table 6** Data set for white/gray background classifier

Number of sample for training	112
Number of sample for validation	24
Number of sample for testing	955

**Table 7** Training for MLP

Actual/prediction	0	1	Precision (%)
0	33	0	100
1	0	79	100
Recall (%)	100	100	
Accuracy (%)			100

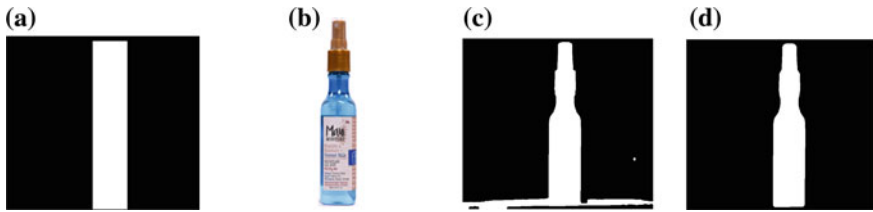
**Table 8** Validation for MLP

Actual/prediction	0	1	Precision (%)
0	8	0	100
1	1	15	93.75
Recall (%)	88.89	100	
Accuracy (%)			95.83

Figure 4c shows background as black and foreground as white pixels. If we look at Fig. 4c, surface noise is presented at bottom of the image. To remove such a noise, we introduced foreground fine-tuning techniques which involve surface removal, median filter, morphological operations. Figure 4d shows clear mask image which does not have any surface noise. Figure 5a and b shows input image and the corresponding output produced by our proposed system, respectively, and background is

**Table 9** Testing for MLP

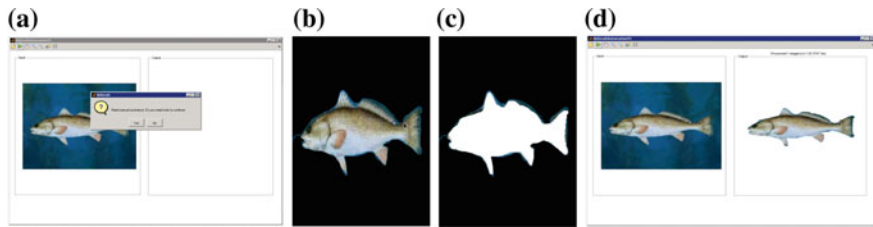
Actual/prediction	0	1	Precision (%)
0	191	6	96.95
1	39	719	94.85
Recall (%)	39	99.17	
Accuracy (%)			95.29



**Fig. 4** **a** Initial contour, **b** projection output, **c** foreground detection, **d** foreground fine-tuning



**Fig. 5** **a** Raw input image, **b** output automation, **c** GUI output white/gray background, **d** GUI output different background



**Fig. 6** **a** Different background image, **b** background selection, **c** foreground selection, **d** GUI semi-automation result

filled with white pixels (clear background). Figure 5c shows GUI representation of input sample images and desired output image with full automation. The above process will be applicable to white/gray color background and as well as monochrome gradient background images. Figure 5d shows the monochrome gradient background-removed results.

Let us consider the input image has natural scene as background and as well as textures variations, and it is shown in Fig. 6. Now, we introduced a semi-automation-based background removal.

In this case, user has to select both background regions. In Fig. 6b, foreground region (filled with black pixels) is selected. In Fig. 6c, background region is selected (filled with white pixels). The desired output is shown in Fig. 6d. Some of the challenged input images and corresponding results are shown in Fig. 7.

The proposed system has been tested and validated in different conditions. Fine-tuning method I works better for white/gray gradient background product images



**Fig. 7** Sample outcomes

**Table 10** Consolidated results

S. No	Task type	Method	Total number of images	Error	Accuracy (%)
1	Foreground detection using rectangle ROI		955	11	98.85
2	Foreground extraction for white/gray gradient color	Fine-tuning method I	758	43	94.33
3	Foreground extraction for white/gray gradient color	Fine-tuning method II	758	128	83.11
4	Foreground extraction for monochrome gradient	Fine-tuning method I	197	47	76.14
5	Foreground extraction for monochrome gradient	Fine-tuning method II	197	26	86.80
6	Overall accuracy (2–3 combined)		955	85	91.10

as well as without contrasting color images. Fine-tuning method II works better for monochrome gradient (nonwhite/gray) background product images. The proposed system achieves better accuracy for monochrome background product images while fusing method I and II, the error rate and accuracy as shown in Table 10.