Smart fabric inspection using Mimosa pudica plant

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ABSTRACT – REZUMAT

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Fabric quality governing and defect detection are playing a crucial role in the textile industry with the development of high customer demand in the fashion market. This work presents fabric defect detection using the sensitive plant segmentation algorithm (SPSA) which, is developed with the sensitive behaviour of the plant biologically named "Mimosa pudica"i. This method consists of two stages. The first stage enhances the contrast of the defective fabric image and the second stage segments the fabric defects with aid of SPSA. The proposed work SPSA is developed for defective pixels identification in both uniform and non-uniform patterns of fabrics. In this work, SPSA has been done by checking with devised condition, correlation and error probability. Every pixel will be checked with the developed algorithm, to get marked either defective or non-defective pixels. The proposed SPSA has been tested on the different types of fabric defect databases and shows a prodigious performance over existing methods like the Differential evolution based optimal Gabor filter model (DEOGF), Gabor filter bank (GFB), Adaptive sparse representation-based detection model (ASR) and Fourier and wavelet shrinkage (FWR).

Keywords: *correlation, error probability, sensitive plant, segmentation, uniform pattern*

Inspecţia inteligentă a materialelor textile folosind planta Mimosa pudica

Controlul calităţii materialelor textile şi detectarea defectelor joacă un rol crucial în industria textilă, odată cu dezvoltarea cerinţelor ridicate ale clienţilor pe piaţa modei. Această lucrare prezintă detectarea defectelor materialului textil folosind algoritmul de segmentare a plantelor sensibile (SPSA), care este dezvoltat pe baza comportamentului sensibil al plantei denumită biologic „Mimosa pudica". Această metodă constă din două etape. Prima etapă îmbunătăţeşte contrastul imaginii materialului textil defect, iar a doua etapă segmentează defectele materialului textil cu ajutorul SPSA. Lucrarea propusă este dezvoltată pentru identificarea pixelilor defecţi în modele uniforme şi neuniforme ale materialelor textile. În această lucrare, SPSA a fost realizat prin verificarea faţă de condiţia concepută, corelaţia şi probabilitatea de eroare. Fiecare pixel va fi verificat cu algoritmul dezvoltat, pentru a fi marcat fie pixel defect, fie fără defect. SPSA propus a fost testat pe diferite tipuri de baze de date cu defecte de materiale textile şi arată o performanţă ridicată faţă de metodele existente, cum ar fi modelul de filtru optim Gabor bazat pe evoluţie diferenţială (DEOGF), bancul de filtre Gabor (GFB), modelul de detectare adaptativ bazat pe reprezentare rară (ASR) şi contracţia Fourier şi cea de tip wavelet (FWR).

Cuvinte-cheie*: corelaţie, probabilitate de eroare, plantă sensibilă, segmentare, model uniform*

INTRODUCTION

Defect detection is greatly significant for textile quality control. Conventionally, defects are detected by human eyes. The effectiveness of this labour-intensive process is low and the missed rate is high because of eye tiredness. Hence, an automatic examination scheme is compulsory for textile industries [1–9].

Due to the weaving course of cloth products, cloth images naturally encompass periodic texture patterns. The look of fabric defects, though, causes local deformation of the normal texture pattern, which indicates that a class of defects locally produces a dissimilar set of textures [10, 11]. Many diverse weaving patterns are there in creating diverse fabric patterns and finding differences between them is not easy [12, 13].

PROPOSED METHOD

This work proposes a defect detection model which is developed based on the sensitive behaviour of a sensitive plant biologically named *Mimosa pudica*. First, all images are pre-processed through Adaptive Intensity Transformation to enhance image contrast. The second step involves the segmentation process developed with the base of the sensitiveness behaviour of *Mimosa pudica* to segment the various pattern of fabrics. The conditions have been resulting in different patterns of fabric to easily section and segregate the defects with a superior degree of precision and accuracy. On the whole, the proposed process consists of two processes namely, pre-processing and segmentation with a sensitive plant algorithm. Contrast enhancement progresses the perceptibility of objects in the scene by enhancing the clarity difference between the objects and their backgrounds. In this work, a fresh contrast enhancement approach based on dominant brightness level analysis and adaptive intensity transformation of images has been chosen.

Segmentation using sensitive plant algorithm

The segmentation process has been developed based on the sensitive behaviour of the *Mimosa pudica* plant. The sensitive plant is also known as **a** humble plant which is the pea family of Fabaceae which is sensitive to touch and other external simulations so instantly closing its leaves and drooping. This plant gives unusually quick responses to the simulation (touch) by sudden water release from leaflets due to the specialized cells. Then the plant comes back to normal after several minutes. It droops in the sense to defend itself against the herbivores. The leaves of the plant also droop in response to darkness and reopen with the daylight known as nyctastic movement shown in figure 1.

a ***b*** ***c***

Fig. 1. Images of: *a* – *Mimosa pudica* plant; *b* – leaves of the plant in normal environmental conditions; *c* – leaves drooped in response to the external stimuli

As a result, the leaves of the sensitive plant droop when affected by external stimuli to protect themselves from predators and it does not droop and act normally with normal environmental conditions. With this sensitivity behaviour, the conditions have been derived for various patterns of the fabric to extract the defective pixels. The missing yarn, stain marks, holes and knotted yarns are said to be defects in the fabric textures. Three different patterns of fabrics plain, twill and satin are checked with the conditions derived for each to find the defective pixels.

Uniform pattern – plain texture pattern

The segmentation process to detect the defective pixel in a plain fabric pattern is done by checking the conditions relative to the sensitiveness of the *Mimosa pudica* plant. The image chosen for the detection will have *MxN* pixels. Let us take the random pixel *p(x,y)* which is chosen for checking as the *Mimosa pudica* plant and its intensity the corresponding pixel is denoted as $I\{p(x,y)\}$.

The chosen pixel has to satisfy the two conditions derived to detect the defects in the plain pattern. The first condition checks the pixels at the top, down, right and left of the selected pixel shown in figures 2 and 3. The first condition is the following:

$$I(P_{x,y}) \neq \{I(P_{x+1,y}), (P_{x,y+1}), (P_{x-1,y}), (P_{x+1,y})\} \quad (1)$$

and the second condition checked with the diagonal pixels around the selected pixel.

$$I(P_{x,y}) \neq \{I(P_{x+1,y+1}), (P_{x-1,y+1}), (P_{x-1,y-1}), (P_{x+1,y+1})\} \quad (2)$$

P(x–1, y–1)	P(x, y+1)	P(x+1, y–1)
P(x–1, y)	P(x, y)	P(x+1, y)
P(x–1, y+1)	P(x, y+1)	P(x+1, y+1)

Fig. 2. Green pixels – four neighbourhood pixels of the pixel *p*(*x*,*y*) and brown pixels – diagonal neighbour pixel of the pixel *p*(*x*,*y*)

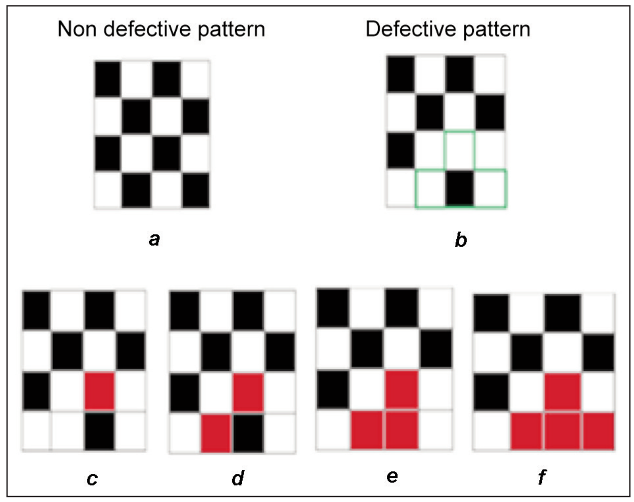


Fig. 3. Step-by-step process of defective pixels identification in a plain pattern

The chosen random pixel (plant) is said to be non-defective, if it satisfies both above conditions, If not, the pixel will be marked (plant droops in response to the stimuli) as the defective one. In this manner, all the pixels in the image will be checked one by one to mark the whole area of the defect. The condition devised will be checked for every pixel starting from the pixel $P_{1,1}$ in the 1st row 1st column In the above-given pattern while checking the pixel $P_{2,2}$ at the 2nd row 2nd column, it could violate the second condition even though it is not the defective one.

$$\rho(P_{x,y}) = \frac{1}{8}\,(\text{no of 4 neighbourhood pixel violating conditon + no of diagonal pixel violating condition}) \quad (3)$$

In that case, Error probability checking will be done.

$$\text{Probability} = \rho(P_{x,y}, P_{x+a,y+b}) \quad (4)$$

With the calculated value of probabilities, the pixel with a higher probability will be chosen as a defective one and will be marked for defect identification. By checking condition and error probability, the pixel will either be marked as defective or leave ideal as non-defective.

Twill texture pattern

The twill pattern of the fabric is among the most widely used weaves within textile production shown in

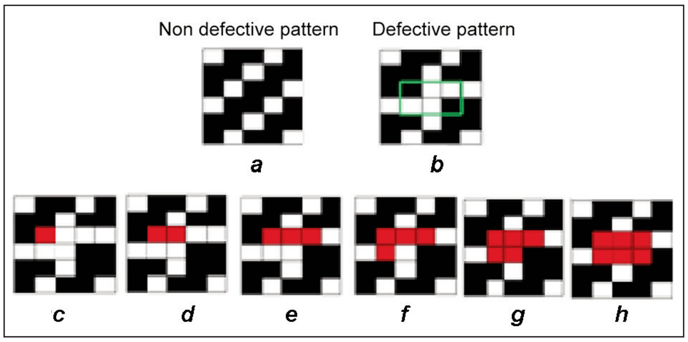


Fig. 4. Step-by-step process of defective pixels identification in a twill pattern

figure 4. It can be easily identified by its pattern of diagonal lines. we check the selected pixel with only its 4 neighbourhood pixels but not with diagonal pixels.

The first condition comprises checking conditions for 8 neighbourhood pixels:

$$I(P_{x,y}) = \{I(P_{x+1,y}), I(P_{x,y+1})\} \text{ AND}$$
$$I(P_{x,y}) \neq \{I(P_{x-1,y}), I(P_{x,y-1})\}$$
$$\{I(P_{x,y}) = I(P_{x-1,y+1}), I(P_{x+1,y-1}), I(P_{x-1,y-1})\} \text{ AND}$$
$$I(P_{x,y}) \neq I(P_{x+1,y+1}) \quad (5)$$

The second condition is the following:

$$I(P_{x,y}) \neq \{I(P_{x+1,y}), I(P_{x,y+1})\} \text{ AND}$$
$$I(P_{x,y}) = \{I(P_{x-1,y}), I(P_{x,y-1})\}$$
$$\{I(P_{x,y}) = I(P_{x-1,y+1}), I(P_{x+1,y-1}), I(P_{x-1,y-1})\} \text{ AND}$$
$$I(P_{x,y}) \neq I(P_{x+1,y+1}) \quad (6)$$

The third condition is the following:

$$I(P_{x,y}) \neq \{I(P_{x+1,y}), I(P_{x,y+1}), I(P_{x-1,y}), I(P_{x,y-1})\}$$
$$\{I(P_{x,y}) = I(P_{x-1,y+1}), I(P_{x+1,y-1})\} \text{ AND}$$
$$I(P_{x,y}) \neq \{I(P_{x-1,y-1}), I(P_{x+1,y+1})\} \quad (7)$$

The selected pixel is checked with three conditions developed.

RESULTS AND DISCUSSION

This section consists of a performance evaluation of the proposed fabric defect detection with the two databases. The first database is the TILDA database, which is the outcome of the workshop on texture analysis of Deutsche Forschungsgemeinschaft Germany. The second database comprises both defective and defective free samples acquired from an apparel factory in Mainland China and scanned from the fabric defect handbook (table 1, figure 5).

Table 1

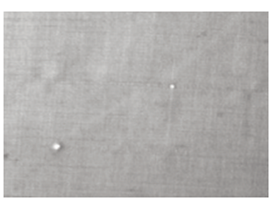
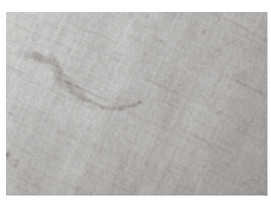
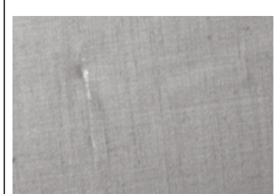
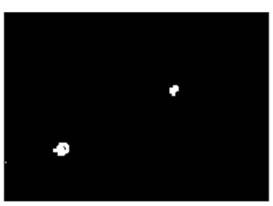
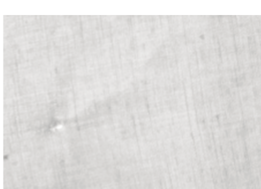
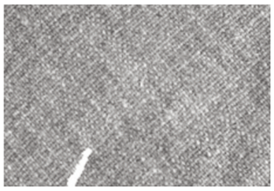
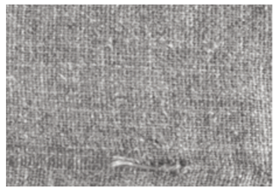
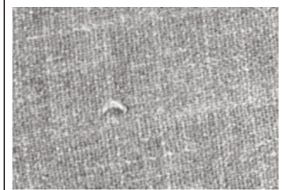
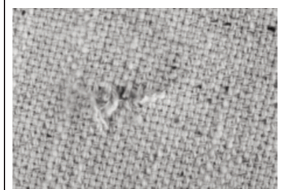
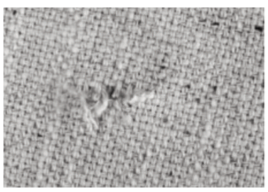
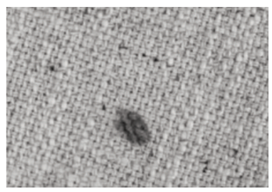
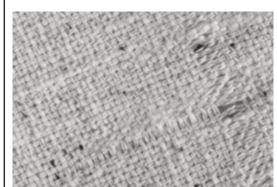
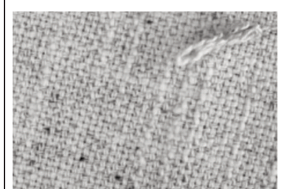
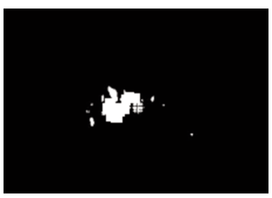
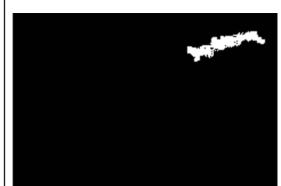
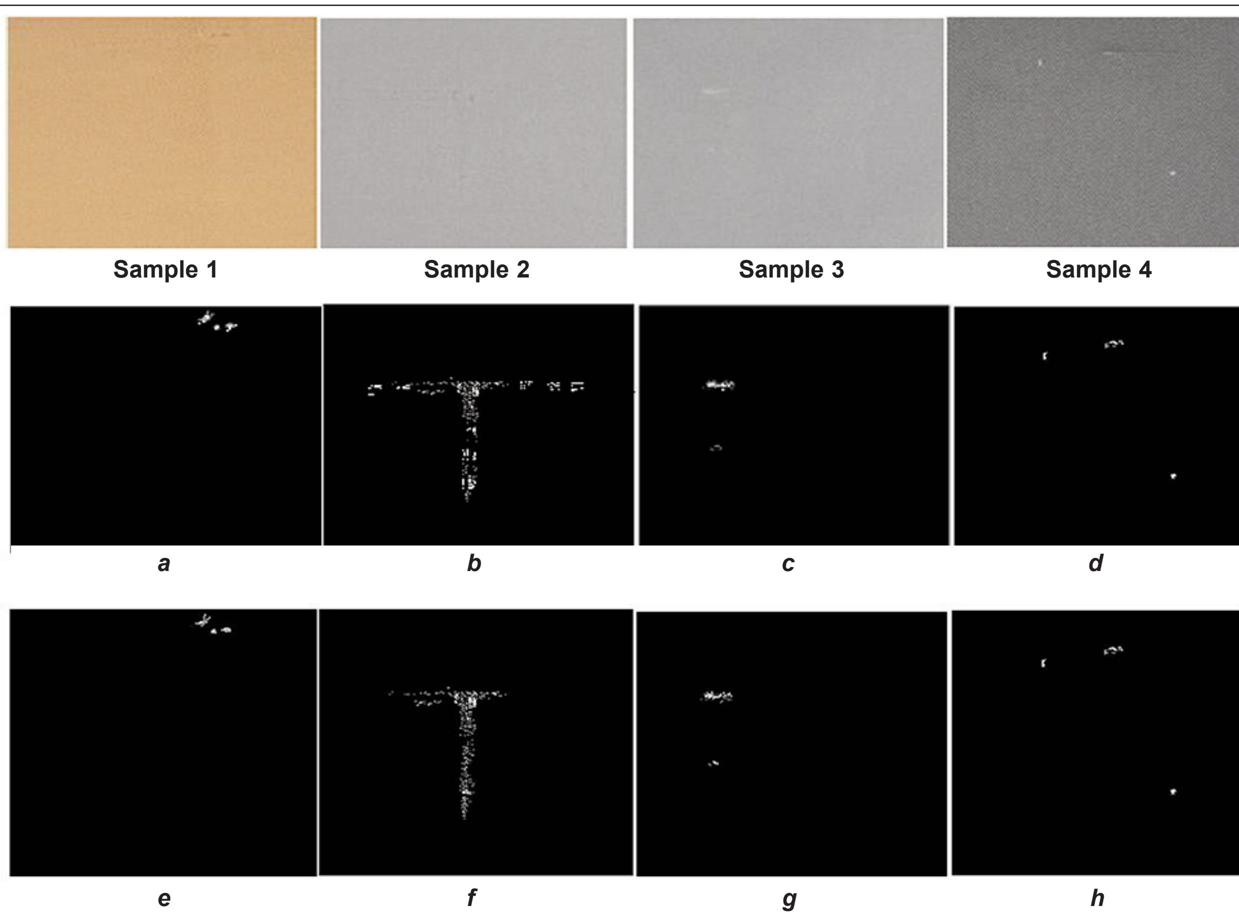
SEGMENTED RESULTS OF THE TILDA DATABASE				
Type/Defects	Holes	Stain	Missing yarn	Spot
I				
				
II				
				

Table 1 (continuation)

Type/Defects	Holes	Stain	Missing Yarn	Spot
III				
				
IV				
				



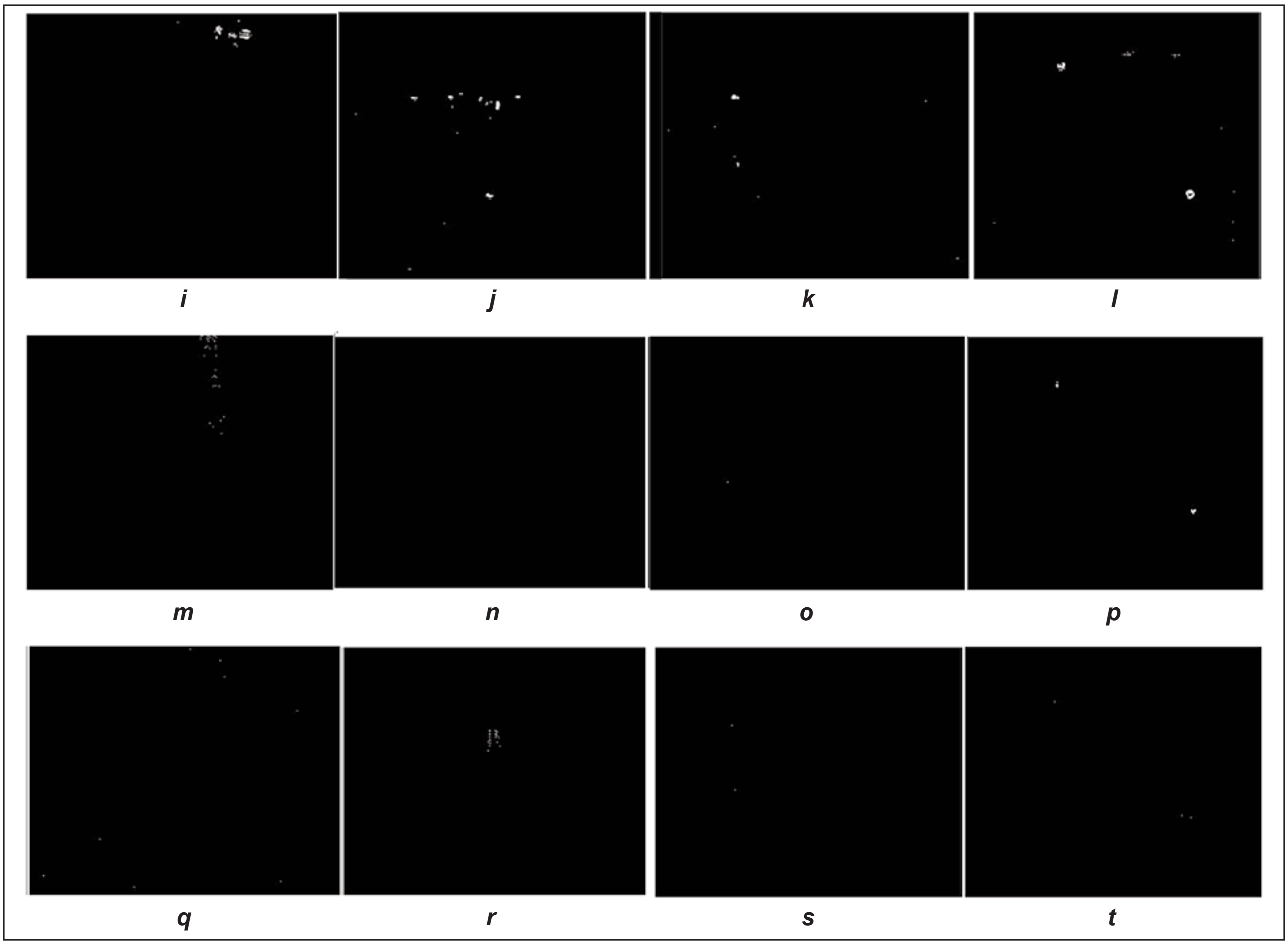


Fig. 5. Detection results of twill fabric compared with existing methods sample image:
a-d – proposed method; *e-h* – NSR; *i-l* – DEOGF; *m-p* – GBF; *q-t* – ASR

Performance metric

Further, the proposed model is compared with traditional methods to show its efficiency. Compared with the five defect detection models, its performance depends on the metrics Precision, Sensitivity, specificity and accuracy (table 2, figure 6).

Table 2

PERFORMANCE COMPARISON TABLE OF PROPOSED AND CONVENTIONAL WORK						
Metrics	**Proposed method**	**NSR**	**DEOGF**	**GFB**	**ASR**	**FWS**
Precision	93.6	92.5	94.7	79.3	93.3	82.7
Sensitivity	97.2	96.1	88.2	81.2	82.3	88.2
specificity	92.2	92.2	95.1	95.1	94.1	79.1
Accuracy	95.8	94.1	91.7	91.7	88.2	83.5

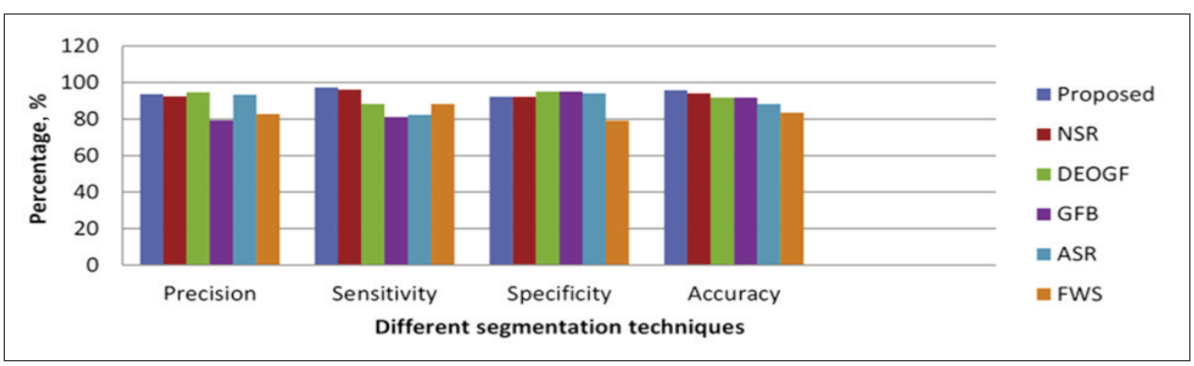


Fig. 6. Performance comparison of different segmentation techniques

CONCLUSION

This work presented a fabric defect detection algorithm developed based on the sensitive behaviour of the sensitive plant algorithm. Detection has been done in two processes: (i) contrast enhancement and (ii) segmentation. The algorithm has developed in a sense to detect defects in both plain and twill texture patterns. The sample images with various types of defects have been used for defect detection and those results are all compared with past developed research. The result complied that the proposed work can detect the most type of defects even if it is tiny and with uneven illumination. It also achieved a high percentage of precision, sensitivity and accuracy of 96% over the other work with a higher detection rate of true positive pixels and lower false alarm pixels.

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