

## **Fuzzy SHmath.Mbio-transform generalization and application to skin cancer imaging (distributed diseases)**

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### **Abstract**

Fuzzy integral transformations are an important methodology for solving the relevant fuzzy boundary (initial) value issues that arise from solving fuzzy differential and integral equations. In this study, the way we classify the-for the corresponding-order fuzzy derivative, fuzzy Shmath.mbio.M-transform. Studies of this process are conducted on the assumption of substantial generalized Hukuhara differentiability. When comparing the suggested transform to another transform, the fuzzy Laplace transform, the effectiveness of the proposed transform in extracting melanoma edges was shown to be much higher. The accuracy and efficiency of the proposed transformation may be enhanced even more. statistical parameters were used to corroborate the findings.

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**Subject Classification:** 03Cxx, 03-XX, 03Exx.

**Keywords:** Mathematical modeling, Ordinary differential equations, Generalization of S.M-transform, Process image, Image skin cancer.

### **1. Introduction**

Fuzzy start and boundary value issues have been the focus of a number of different approaches[1, 2, 3]. Fuzzy transformations are often used

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to solve these differential equations and integral equations. Differential equations[14,15]. Two examples of classical transformations[11,12,13] that have been turned into fuzzy transforms are the Laplace transform[4,5,6,7] and the Somodo transform[8,9,10]. To that end, this paper presents a generalization of The transformation technique (the -order fuzzy derivative) was discussed, and the proposed transformation was applied to skin cancer and compared with the fuzzy Laplace transform as shown, as well as analysis and classification of skin burn cancer stages with statistical parameters.

## 2. Basic concepts

**Definition 1:** Let  $\varphi(\sigma)$  be a continuous fuzzy-valued function Suppose that  $\cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \varphi(\sigma) d\sigma$  is improper fuzzy Riemann-integrable on  $[0, \infty)$ , then  $\cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \varphi(\sigma) d\sigma$  is called  $\widehat{SHmath.MAbio}$ -transform and it denoted by:

$$\begin{aligned} \widehat{SHmath.MAbio}[\varphi(\sigma)] &= \widehat{SHmath.MAbio}(\varepsilon) = \cos n\varepsilon (\sin n\varepsilon + \varepsilon) \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \varphi(\sigma) d\sigma \\ \cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \varphi(\sigma) d\sigma &= \cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \underline{\varphi}(\sigma; \phi) d\sigma, \\ \cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \overline{\varphi}(\sigma; \phi) d\sigma & \end{aligned}$$

Using the definition of classic  $SHmath.MAbio$ -transform

$$\begin{aligned} \widehat{SHmath.MAbio}[\underline{\varphi}(\sigma; \phi)] &= \cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \underline{\varphi}(\sigma; \phi) d\sigma, \\ \widehat{SHmath.MAbio}[\overline{\varphi}(\sigma; \phi)] &= \cos n\varepsilon \int_0^\infty e^{-(\sin n\varepsilon + \varepsilon)\sigma} \overline{\varphi}(\sigma; \phi) d\sigma \\ \widehat{SHmath.MAbio}[\varphi(\sigma; \phi)] &= \widehat{SHmath.MAbio}[\underline{\varphi}(\sigma; \phi)], \widehat{SHmath.MAbio}[\overline{\varphi}(\sigma; \phi)] \end{aligned}$$

**Theorem 2:** Let  $\mathfrak{Z}(\delta)$  by fuzzy function  $\delta \geq 0$ ,  $\eta(\varepsilon) = \cos n\varepsilon$ ,  $\varepsilon \neq 0$  be positive real function and  $\beta(\varepsilon) = e^{-(\sin n\varepsilon + \varepsilon)\sigma}$ ,  $\varepsilon \neq 0$  be positive complex function then the derivatives of  $\mathfrak{Z}(\delta)$  for  $n^{\text{th}}$ -order will be as following:

$$\begin{aligned}
1. \quad \widetilde{SHmath.MAbio}\{\delta \, \Im(\delta)\} &= -\frac{\cos n\varepsilon}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{\widetilde{SHmath.MAbio}(\Im(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \\
2. \quad \widetilde{SHmath.MAbio}\{\delta^2 \Im(\delta)\} &= (-1)^2 \frac{\cos n\varepsilon}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{1}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{\widetilde{SHmath.MAbio}(\Im(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \right)' \\
3. \quad \widetilde{SHmath.MAbio}\{\delta^n \Im(\delta)\} &= (-1)^n \\
&\quad \frac{\cos n\varepsilon}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{1}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{1}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \dots \left( \frac{1}{e^{-(\sin n\varepsilon + \varepsilon)\sigma}} \left( \frac{\widetilde{SHmath.MAbio}(\Im(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \right)' \right)' \dots \right)' \right)'
\end{aligned}$$

**Proof:**

1. Since

$$\begin{aligned}
\widetilde{SHmath.MAbio}\{\Im(\delta), \varepsilon\} &= \cos n\varepsilon \int_0^\infty \Im(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \cos n\varepsilon \int_0^\infty \bar{\Im}(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta \\
&\Rightarrow \frac{\widetilde{SHmath.MAbio}\{\Im(\delta), \varepsilon\}}{\cos n\varepsilon} = \int_0^\infty \Im(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \int_0^\infty \bar{\Im}(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta
\end{aligned}$$

**Differential above equation with regard  $\varepsilon$ , to get:**

$$\left( \frac{\widetilde{SHmath.MAbio}\{\Im(\delta), \varepsilon\}}{\cos n\varepsilon} \right)' = \frac{d}{d\varepsilon} \left[ \int_0^\infty \Im(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \int_0^\infty \bar{\Im}(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta \right]$$

From equation (1), to get:

$$\begin{aligned}
\left( \frac{\widetilde{SHmath.MAbio}\{\Im(\delta), \varepsilon\}}{\cos n\varepsilon} \right)' &= -(\sin n\varepsilon + \varepsilon) \frac{\widetilde{SHmath.MAbio}\{\Im(\delta; \varepsilon), \varepsilon\}}{\cos n\varepsilon}, \\
&\quad -(\sin n\varepsilon + \varepsilon) \frac{\widetilde{SHmath.MAbio}\{\bar{\Im}(\delta; \varepsilon), \varepsilon\}}{\cos n\varepsilon} \\
\left( \frac{\widetilde{SHmath.MAbio}(\Im(\delta), \varepsilon)}{\cos n\varepsilon} \right)' &= -((\sin n\varepsilon + \varepsilon)) \frac{\widetilde{SHmath.MAbio}\{\delta \, \Im(\delta), \varepsilon\}}{\cos n\varepsilon}
\end{aligned}$$

Then, to get:

$$\widehat{SHmath.MAbio}\{\delta \, \mathfrak{Z}(\delta), \varepsilon\} = -\frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \left( \frac{\widehat{SHmath.MAbio}(\mathfrak{Z}(\delta), \varepsilon)}{\cos n\varepsilon} \right)'$$

By calculating the derivatives of both sides of the given equation:

$$-\frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \int_0^\infty \delta^2 \mathfrak{Z}(\delta; \varepsilon) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, -(\sin n\varepsilon + \varepsilon) \int_0^\infty \delta^2 \bar{\mathfrak{Z}}(\delta; \varepsilon) e^{-((\sin n\varepsilon + \varepsilon))\delta} d\delta$$

$$\widehat{SHmath.MAbio}\{\delta^2 \mathfrak{Z}(\delta)\} =$$

$$(-1)^2 \frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \left( -\frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \left( \frac{\widehat{SHmath.MAbio}(\mathfrak{Z}(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \right)'$$

### 3. The third element may be proved in a similar fashion

$$\widehat{SHmath.MAbio}\{\delta^2 \mathfrak{Z}(\delta)\} =$$

$$(-1)^2 \frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \left( -\frac{1}{(\sin n\varepsilon + \varepsilon)} \left( \frac{\widehat{SHmath.MAbio}(\mathfrak{Z}(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \right)'$$

derivative both side of above equation (n-2)-Times, we get

$$\widehat{SHmath.MAbio}\{\delta^n \mathfrak{Z}(\delta)\} = (-1)^n$$

$$\frac{\cos n\varepsilon}{(\sin n\varepsilon + \varepsilon)} \left( \frac{1}{(\sin n\varepsilon + \varepsilon)} \left( \frac{1}{(\sin n\varepsilon + \varepsilon)} \left( \dots \left( \frac{1}{(\sin n\varepsilon + \varepsilon)} \left( \frac{\widehat{SHmath.MAbio}(\mathfrak{Z}(\delta), \varepsilon)}{\cos n\varepsilon} \right)' \right)' \right)' \right)' \dots \right)'$$

**Theorem 3:** Let  $\eta(\varepsilon) = \cos n\varepsilon$  and  $\beta(\varepsilon) = (\sin n\varepsilon + \varepsilon)$  functions which may undergo differentiation, with the requisite  $\mathfrak{Z}(\delta)$  then the function is a fuzzy one

$$\widehat{SHmath.MAbio}\{\delta \mathfrak{Z}^{(n)}(\delta)\} = -\frac{\cos n\varepsilon}{\sin n\varepsilon + \varepsilon} \frac{d}{d\varepsilon} \left( \frac{\widehat{SHmath.MAbio}(\mathfrak{Z}^{(n)}(\delta))}{\cos n\varepsilon} \right)$$

**Proof:**

$$\begin{aligned} \widehat{SHmath.MABio\{\mathfrak{I}^{(n)}(\delta), \varepsilon\}} &= \cos n\varepsilon \int_0^\infty \underline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \\ &\quad \cos n\varepsilon \int_0^\infty \overline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta \\ \frac{\widehat{SHmath.MABio\{\mathfrak{I}^{(n)}(\delta), \varepsilon\}}}{\cos n\varepsilon} &= \int_0^\infty \underline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \int_0^\infty \overline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta \end{aligned} \quad (2)$$

The above equation is differentiated with regard to  $\varepsilon$ , then:

$$\frac{d}{d\varepsilon} \left[ \frac{\widehat{SHmath.MABio\{\mathfrak{I}^{(n)}(\delta), \varepsilon\}}}{\cos n\varepsilon} \right] = \left[ \int_0^\infty \underline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta, \int_0^\infty \overline{\mathfrak{I}}^{(n)}(\delta; \vartheta) e^{-(\sin n\varepsilon + \varepsilon)\delta} d\delta \right]$$

From equation 2:

$$\begin{aligned} \frac{d}{d\varepsilon} \left[ \frac{\widehat{SHmath.MABio\{\mathfrak{I}^{(n)}(\delta), \varepsilon\}}}{\cos n\varepsilon} \right] &= -(\sin n\varepsilon + \varepsilon) \frac{\widehat{SHmath.MABio\{\delta \underline{\mathfrak{I}}^{(n)}(\delta; \vartheta), \varepsilon\}}}{\cos n\varepsilon}, \\ &\quad -(\sin n\varepsilon + \varepsilon) \frac{\widehat{SHmath.MABio\{\delta \overline{\mathfrak{I}}^{(n)}(\delta; \vartheta), \varepsilon\}}}{\cos n\varepsilon} \\ \widehat{SHmath.MABio\{\delta \mathfrak{I}^{(n)}(\delta)\}} &= -\frac{\cos n\varepsilon}{\sin n\varepsilon + \varepsilon} \frac{d}{d\varepsilon} \left( \frac{\widehat{SHmath.MABio\{\mathfrak{I}^{(n)}(\delta)\}}}{\cos n\varepsilon} \right) \end{aligned}$$

**Theorem 4:** Assume that  $\varphi^{\setminus}(\sigma)$  be continuous fuzzy-valued function and  $\varphi(\sigma)$  the primitive of  $\varphi^{\setminus}(\sigma)$  on  $[0, \infty)$ , we have:

1.  $\widehat{SHmath.MABio}[\varphi^{\setminus}(\sigma)] = (\sin n\varepsilon + \varepsilon) \widehat{SHmath.MABio}[\varphi(\sigma)] \ominus \cos n\varepsilon \varphi(0)$ ,  
where  $\varphi$  is the first form differentiable.
2.  $\widehat{SHmath.MABio}[\varphi^{\setminus\setminus}(\sigma)] = -\cos n\varepsilon \varphi(0) \ominus (-\sin n\varepsilon + \varepsilon) \widehat{SHmath.MABio}[\varphi(\sigma)]$ ,  
where  $\varphi$  is the second form differentiable.

#### 4. Fuzzy $\widehat{SHmath.MABio}$ -Transform for Fuzzy nth-Order Derivative

**Theorem 5:** Assume that  $\mathfrak{I}(\delta), \mathfrak{I}^{\setminus}(\delta), \dots, \mathfrak{I}^{n-1}(\delta), \mathfrak{I}^{(n)}(\delta)$  are fuzzy valued functions with a continuous domain on  $[0, \infty)$  of exponential magnitude, and the fact  $\mathfrak{I}^{(n)}(\delta)$  be Continuously Fuzzy Pricing on a Continuum of Costs  $[0, \infty)$ . Let  $\mathfrak{I}^{(i_1)}(\delta), \mathfrak{I}^{(i_2)}(\delta), \dots, \mathfrak{I}^{(i_p)}(\delta)$  are functions that can differentiate by a second

order  $0 \leq i_1 \leq i_2 \leq \dots \leq i_\varphi \leq n-1$  and  $\mathfrak{Z}^{(p)}$  be first form differentiable function for  $p \neq i_j, j=1, 2, \dots, \varphi$ , then:

1. If  $\varphi$  is an even number, we have

$$M(\mathfrak{Z}^{(n)}(\delta)) = (\sin n\varepsilon + \varepsilon)^n M(\mathfrak{Z}(\delta)) \ominus \cos n\varepsilon (\sin n\varepsilon + \varepsilon) \mathfrak{Z}(0) \textcircled{\text{R}} \sum_{\kappa=1}^{n-1} \varepsilon^{n-\kappa+1} \mathfrak{Z}^{(\kappa)}(0)$$

such that

$$\textcircled{\text{R}} = \begin{cases} \ominus, & \text{The second form allows for distinct differentiation based on} \\ & \text{the frequency of repetitions } i_1, \dots, i_\kappa \text{ if and only if it an even number} \\ -, & \text{Can the second type be distinguished from the first by the} \\ & \text{total number of occurrences } i_1, \dots, i_\kappa \text{ seems to be an odd number} \end{cases}$$

2. If  $\varphi$  is an odd number, we have

$$M(\mathfrak{Z}^{(n)}(\delta)) = -\cos n\varepsilon^{n+1} \mathfrak{Z}(0) \ominus (-\cos n\varepsilon^n) M(\mathfrak{Z}(\delta)) \textcircled{\text{R}} \sum_{\kappa=1}^{n-1} \cos n\varepsilon^{n-\kappa+1} \mathfrak{Z}^{(\kappa)}(0)$$

**Proof:** The proof depends on the duality between fuzzy Laplace-Fuzzy

$\overline{SHmath.MAbio}$ -Transforms from as follows  $\overline{SHmath.MAbio}(\varepsilon) =$

$\overline{SHmath.MAbio}[\mathfrak{Z}(\varepsilon)]$   $F(p) = L[\mathfrak{Z}(\mathfrak{N})]$  and  $F_n(p) = L[\mathfrak{Z}^{(n)}(\mathfrak{N})]$  From duality

relation (1), we have  $\overline{SHmath.MAbio_n}(\delta) = \overline{SHmath.MAbio}[\mathfrak{Z}^{(n)}(\delta)] = \cos n\varepsilon F_n$

$(\sin n\varepsilon + \varepsilon)$  Let  $\varphi$  is an even number. Then from theorem 4 when  $\varphi$  is an even number, equation 2 becomes

$$\begin{aligned} \overline{SHmath.MAbio_n}(\delta) &= \cos n\varepsilon \\ &\left[ (\sin n\varepsilon + \varepsilon)^n F(\sin n\varepsilon + \varepsilon) \ominus (\sin n\varepsilon + \varepsilon)^{(n-1)} \mathfrak{Z}(0) \right] \sum_{\kappa=1}^{n-1} (\sin n\varepsilon + \varepsilon)^{n-(\kappa+1)} \mathfrak{Z}^{(\kappa)}(0) \\ &= (\sin \varepsilon + \varepsilon)^n \overline{SHmath.MAbio}[\mathfrak{Z}(\delta)] \ominus \varepsilon (\sin \varepsilon + \varepsilon)^{(n-1)} \mathfrak{Z}(0) \\ &\textcircled{\text{R}} \text{ one } \sum_{\kappa=1}^{n-1} (\sin \varepsilon + \varepsilon)^{n-(\kappa+1)} \mathfrak{Z}^{(\kappa)}(0) \end{aligned}$$

Let  $\varphi$  is an odd number. Then from theorem 4, equation (3) becomes:

$$\begin{aligned} &= -\cos n\varepsilon (\sin n\varepsilon + \varepsilon)^{(n-1)} \mathfrak{Z}(0) \ominus (-\sin n\varepsilon + \varepsilon)^n \\ &\overline{SHmath.MAbio}[\mathfrak{Z}(\delta)] \cos n\varepsilon \sum_{\kappa=1}^{n-1} (\sin n\varepsilon + \varepsilon)^{n-(\kappa+1)} \mathfrak{Z}^{(\kappa)}(0) \end{aligned}$$

#### 4. Application

The following Classification skin cancer (distributed diseases) the usage of *SHmath.MAbio*-transform.

##### 4.1 System Analysis and Design

In this part, various image processing approaches were used to achieve Automatic Border (Types of Diseases) Identification, and then it will be classified with the of fuzzy *SHmath.MAbio*-transform. The developed system works on RGB color images with size 128 x 128 pixel. The system is built with four primary processes these are explained in Figure (1-1).

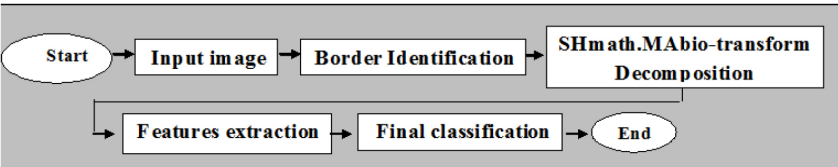


Figure (1-1)

Main stages for the Automatic Border (skin cancer (distributed diseases)) Identification

#### The system database:

Each stage of the Mycosis Fungoides disease is represented by one of the database's 40 photos (See Figures 2-6 and Tables 1 & 2). An image of your skin Ten pictures for each phase Skin imaging databases of two categories were used in this study:

1. Database developed in our conditions, photos taken from Al-Sder Hospital.2.The Skin Database [4] and some other photos retrieved from: A coetaneous T-cell lymphoma, Mycosis is a rare condition. T-lymphocyte proliferation, also known as helper T cell proliferation, is the underlying cause of the disease, which is why the disease is in its early stages: Stage 1: The cancer only affects a small portion of the skin, resulting in red, dry, and scaly patches, but no tumors have yet formed. The lymph nodes do not appear to be any larger than usual. Stage 2: The skin is red, dry, and scaly in areas, but there are no tumors, but free of any cancerous cells Tumors can be seen on the skin. Normal or larger than normal lymph nodes do not contain cancerous cells. Stage 3: The skin has turned red, dry, and

scaly across much of its surface. The lymph nodes are either normal Stage 4: Involvement of the skin as well as any of the following. A cancerous tumor’s lymph nodes The cancer has progressed to other organs including the liver or lungs



Figure (2-2)  
Database Consists of 36 Images

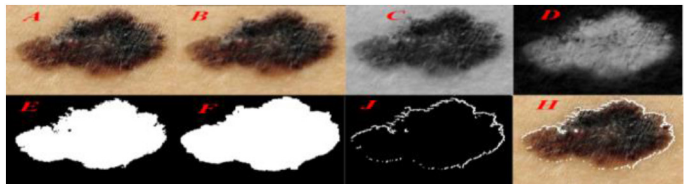
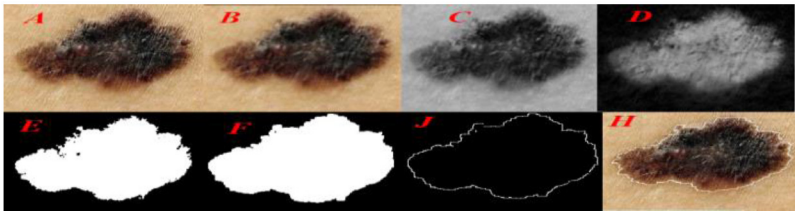


Figure (3-3)  
(A) Color original image of skin cancer (B)noise removing (C) image obtain after mapping colors into intensity (D)difference between each pixel in image and the mean of background (E) threshold of difference image (F)filling operator to threshold image (J) Laplace edge detection (H)OR operator between (A) and (J)



Figure(4-4)  
(A) Color original image of skin cancer (B)noise removing (C) image obtain after mapping colors into intensity (D) difference between each pixel in image and the mean of background (E) threshold of difference image (F) filling operator to threshold image (J) Fuzzy *SHmath.MAbio*-transform edge detection (H)OR operator between (A)and (J)

Table (1-1)  
Statistics case one

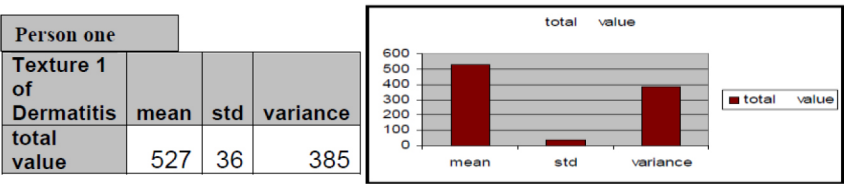
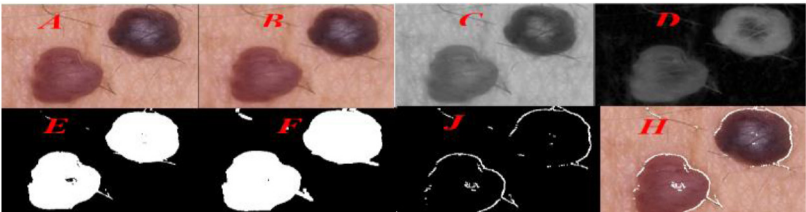


Figure (5-5)

(A) Color original image of skin cancer (B)noise removing (C) image obtain after mapping colors into intensity (D)difference between each pixel in image and the mean of background (E) threshold of difference image (F)filling operator to threshold image (J) Laplace edge detection (H)OR operator between (A) and (J)

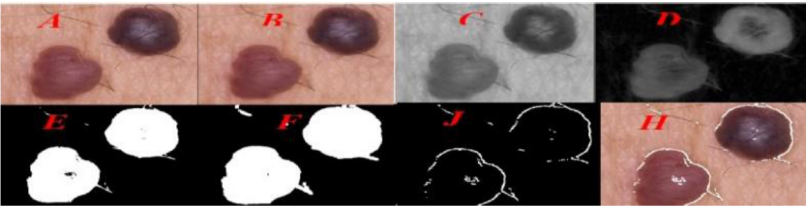
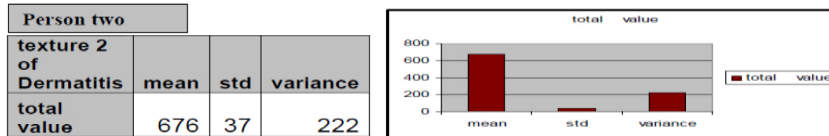


Figure (6-6)

(A) Color original image of skin cancer (B)noise removing (C) image obtain after mapping colors into intensity (D)difference between each pixel in image and the mean of background (E) threshold of difference image (F)filling operator to threshold image (J) Fuzzy *SHmath.MAbio*-transform edge detection (H) OR operator between (A)and (J).

**Table (2-2)**  
**Statistics case two.**



## 5. Conclusion

In this paper, we introduce a comparison between the proposed method and fuzzy Laplace transform to indicate that the results obtained in the proposed method has surpassed the other methods because of its transform is used to adapt to the image content of medical and this adaptation result of edges (national, and Horizontal, and vertical as illustrated in the following: In terms of the shapes:

We find that the shapes (4-4) and (6-6) edges detection using the transfer more than the clarity and the accuracy of shapes (3-3) and (5-5) edges detection using fuzzy Laplace transform. The proposed models are much better in terms of identifying the edges and the cause of the fact that the method in time domain compared with fuzzy laplaces transform as identifying the edges be in the frequency domain, according to scientific studies have preferably used edges detection in the time domain as it deals with the real values of the image of reverse frequency domain, where it deals with the values of transition. For this reasonthe resolution would not be clear in case of fuzzy laplaces transform.

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