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Design and Development of an Area Estimating System to Find the Body Surface Area Affected by Vitiligo Using Simulation Approach

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Abstract— **This paper is an application of our study in the medical field, particularly on vitiligo disease which discuss the problem of assessment of the quantitative parameters which are the factors to check the efficacy of Vitiligo therapy response. These parameters add a extra level of discrepancy when they are assessed by non-standard procedures. The background work is the recordings of the strategies discussed by different Dermatologists and the analysis of the currently existing quantitative parameter clinical tools. Vitiligo Area Scoring Index (VASI) is a clinical tool which evaluates vitiligo parametrically. This paper focuses on consistent estimation of the area of vitiligo patches. In dermatological practice, methods of evaluating the vitiligo affected body surface area are often crude and subjective. The main objective is to control this parameter quantitatively and estimate area with minimum errors. A software – Area Estimating System (AES) is developed with highly performing computerized Java programs which relies on Simulation Techniques.**

Keywords— **Pseudo random numbers, Simulation, Irregular shape, Java GUI, Data Structures.**

I. INTRODUCTION

Earlier the authors had presented a scientific approach to estimate area of irregular shapes. To check the accuracy of this proposed procedure it has been verified with regular shapes [1] , and then extended to a sector curvilinear nature(curved shapes) [2], finally to irregular shapes[3] and overlapped irregular shapes[4]. Java programs were developed for the automation of these procedures. **This paper is concentrating in demonstration and utilization of the above study in medical field and is particularly focussed on Vitiligo disease.** A quantitative approach for estimating and evaluating the medical conditions of a vitiligo treatment is the latest problem as there are very few quantitative tools for measuring the vitiligo treatment response. The vital requirement of this problem is to identify and define definite parameters. The parameter evaluation is a quantified assessment of vitiligo treatment response of a patient. **This paper proposes a new approach for quantification of parameter – area of vitiligo patches.** Quantitative methods produce data for direct estimation and comparison of levels of therapy response which is meaningful to patients and physicians.

II. ABOUT VITILIGO

Vitiligo is a common skin disorder in which the pigment producing cells of the skin (melanocytes) are absent or demonstrate lack of activity. As a result, lighter de-pigmented patches of skin (target lesions) appear in different parts of the body due the lack of melanin (pigment). The exact cause of vitiligo is unknown, but it is generally recognised that an autoimmune component plays a role in this disease. Between 0.1-2% of the global population is affected by vitiligo affecting all races. Vitiligo causes significant psychological and emotional distress.

Vitiligo is traditionally separated into two clinical forms: non segmental, or generalised, vitiligo (NSV) and segmental vitiligo (SV), which present with distinctive clinical features and natural histories. NSV is the most common form of the disease, accounting for 72-95% of the cases. The vitiliginous lesions are usually symmetrically distributed and new patches may appear throughout the patient's life. The disease is progressive with flare-ups. NSV is frequently associated with personal or family history of auto-immunity.

There are several treatments available for vitiligo but on a practical basis the only few literatures or guidelines present to find the efficacy of the vitiligo treatment because of non-standardized methods for assessment factors of vitiligo. The slow response of vitiligo treatment is another crucial factor for

vitiligo treatment response. The main goal of treating vitiligo is to achieve an arrest of the de-pigmentation. It is particularly important for monitoring the response to a therapy and for evaluating the efficacy of drugs specified. To carry this out observations have to parameterized and quantitatively analysed.

III. QUANTITATIVE PARAMETER CLINICAL TOOL

Two scores designed for the assessment of vitiligo are **Vitiligo Area Scoring Index (**VASI), **vitiligo disease activity score** (VIDA) are currently present.

VASI Assessment Factors:

I) Composite Estimation of body surface area: This parameter requires a monthly estimation of body surface area affected by vitiligo. In VASI evaluation method the body is divided into 5 separate and mutually exclusive regions: hands, upper extremities (excluding hands), trunk, lower extremities (excluding feet) and feet. The auxiliary and inguinal regions were included with the upper and lower extremities, respectively, while the buttocks were included with the lower extremities. The face and neck areas were assessed and treated for vitiligo if requested by the patient, but these areas were not included in the overall evaluation One hand unit, which encompasses the palm plus the volar surface of all the digits, is approximately 1% of the total body surface area and was used as a guide to estimate the baseline percentage of vitiligo involvement of each body region. To eliminate variations in hand size, we defined a hand unit to be the volar hand, including fingers, of one of us (I.H.). In Vitiligo management [6] the extent of the person's body surface area that is affected by vitiligo can also be estimated in the same way as for burns The 'Rule of Nines': Arm — 9% ,Head — 9% ,Neck — 1% ,Leg — 18% ,Anterior trunk — 18% ,Posterior trunk — 18%(The Lund and Browder chart)[5]

II) Estimation of degree of pigmentation: The second parameter is Standardized assessments for estimating the degree of pigmentation to derive the Vitiligo Area Scoring Index. At 100% de-pigmentation, no pigment is present; at 90%, specks of pigment are present; at 75%, the de-pigmented area exceeds the pigmented area; at 50%, the de-pigmented and pigmented areas are equal; at 25%, the pigmented area exceeds the de-pigmented area; and at 10%, only specks of de-pigmentation are present.

Formula by considering the contributions of all body regions:

The total body VASI was then calculated using the following formula by considering the contributions of all body regions

$$\text{VASI} = \sum_{\text{All body parts}} [\text{Hand Units}] \times [\text{Residual De-pigmentation}]$$

Thus VASI is scoring system which helps in estimating the periodic treatment response of a vitiligo patient.

IV. OUR NEW PROPOSED APPROACH FOR FIRST ASSESSMENT FACTOR

Unlike VASI method for estimation of first factor (i.e. one hand unit approximation[7] or Rule of Nine for estimation of body surface area[6]) ,in this paper we present a new scientific approach (based on Simulation Technique) in estimating the affected body surface area which is a primary parameter in assessment of periodic treatment response for vitiligo. **Area Estimating System (AES Software) is based on a new approach.** Estimation of area of irregular shape is a significant problem, as no straightforward formula is available. In this direction the authors have tested the AES software for different shapes (regular shapes, irregular shapes with straight-line boundaries and irregular shapes with curved boundaries and overlapped irregular shapes). The results obtained were critically compared with the results obtained by mathematical formula. (Vide [1][2][3][4])

V. AREA ESTIMATING SYSTEM(AES SOFTWARE)

Before presenting the key features and working of AES software lets list out the activities prerequisite necessary for AES software.

5.1 TWO Step process

1. A photograph of vitiligo patch is taken using a camera.
2. The image of vitiligo patch has to saved as a file in the processing unit in .jpg format. For Instance: (Vitiligofig1.jpg filename is a the primary input to AES)

Fig (5.1.1)

5.2 Simulation Procedure to Estimate the area of Irregular Vitiligo patch

Basic steps for developed for estimating area of irregular shape is explained in our paper[4][5].The same procedure is applied to a vitiligo patch as show below. Consider the irregular shape given in Fig (5.2.1)

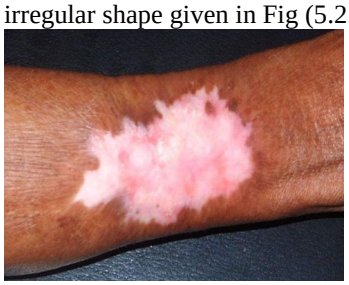


Fig (5.2.1)

STEPS FOLLOWED:

Step 1: Insert the figure in a rectangle as shown in Fig(2.2) , such that sides of rectangle include the minimum And maximum values of irregular shape on X-axis and Y-axis.

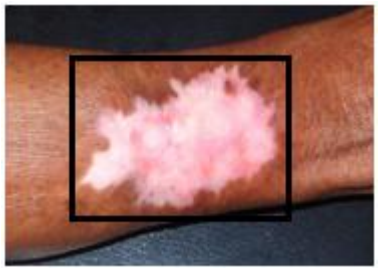


Fig (5.2.2)

Step 2: Identify the co-ordinates of the rectangle and find area of the rectangle denoted by A.

Step 3: Divide rectangle area into number of vertical strips in regular interval on X – axis. Let K represent no. Of strips as shown in Fig(4.2.3)

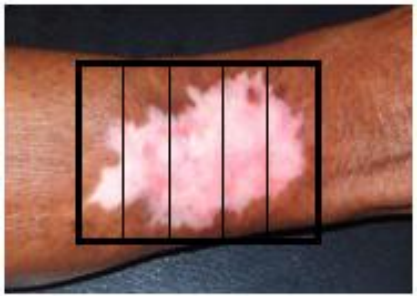


Fig (5.2.3)

Step 4: Identify the min-y and max-y points intersecting the boundary of the irregular shape in each strip. Determine the boundary points and its coordinates under each strip. The total number Of boundary points will be k*2.

Step 5: Generates pseudo random numbers in pairs (x_i, y_i) such that xi on the length of the rectangle and y_i on the breadth of the rectangle such that each pair (x_i, y_i) corresponds to a point on the area of the rectangle.

Step 6: Using iterative procedure determine the no. of generated pairs of random numbers following inside the each strip.

Step 7: Add all points in each strip falling inside the irregular shape and determine the total no. of points in all strips falling inside the given irregular shape.

Step 8: Let $f_{in} = \sum_{I=1}^{n} \mathbf{f_{in}}^{(i)}$

where $f_{in}^{(i)}$ = number Of points inside the irregular shape in i^{th} strip.

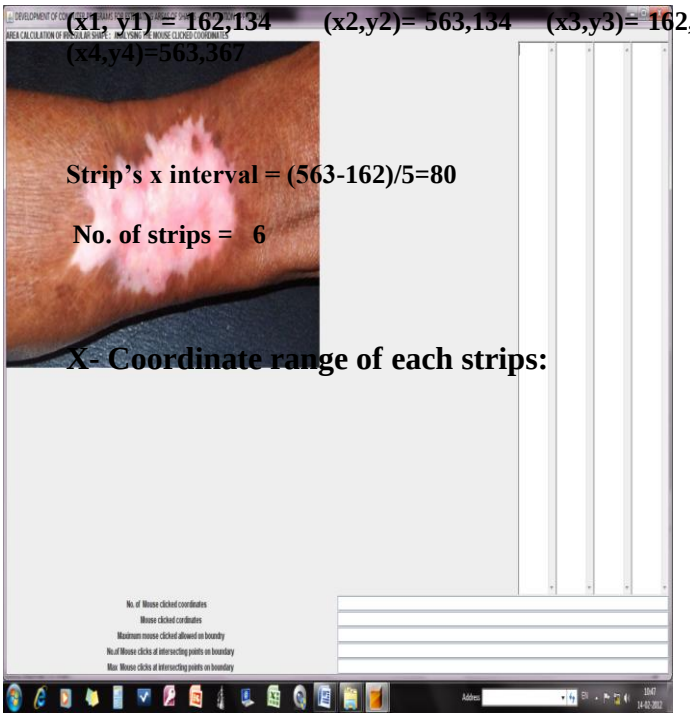
Step 9: Let 'f_{ran}' represents number of random number pairs generated.

Step 10: Estimated Area of the proposed irregular shape denoted by Â is given by

$$\hat{A} = f_{in} / f_{ran} * A$$

5.3 About AES (software) features: The above explained procedure is automated using high performing JAVA programs which has features ranging from the basic Object-Oriented programming, Advanced Class Features, Graphics class, Collection API's, Generics, Iterators, Java GUI's, GUI Event Handlers[8][9].

VI. DEMONSTRATION OF THE PROCEDURE TO A VITILIGO AFFECTED AREA USING AES (SOFTWARE):



Strip1 to 2	Strip 2to 3	Strip 3 to 4
177-238	238-320	320-402

Strip 4 to 5	Strip 5 to 6
402-481	481-559

Fig (6.1)

Table (6.2)

The coordinates of 20 clicked points on the image:

P1 (361,367)	**P7 (272,190)**
P2(328,363)	**P8(425,134)**
P3(258,316)	**P9(470,140)**
P4(162, 330)	**P10(527,189)**
P5(189, 278)	**P11(553,197)**
P6(201 ,208)	**P12(556,239)**
P13 (563,277)	**P19 (275,346)**
P14(439,348)	**P20(337,327)**
P15(380,367)	
P16(344, 367)	
P17(293, 359)	
P18(301 ,367)	

Table (6.1)

Rectangle is drawn with the coordinates:

The strips in the image is shown below:

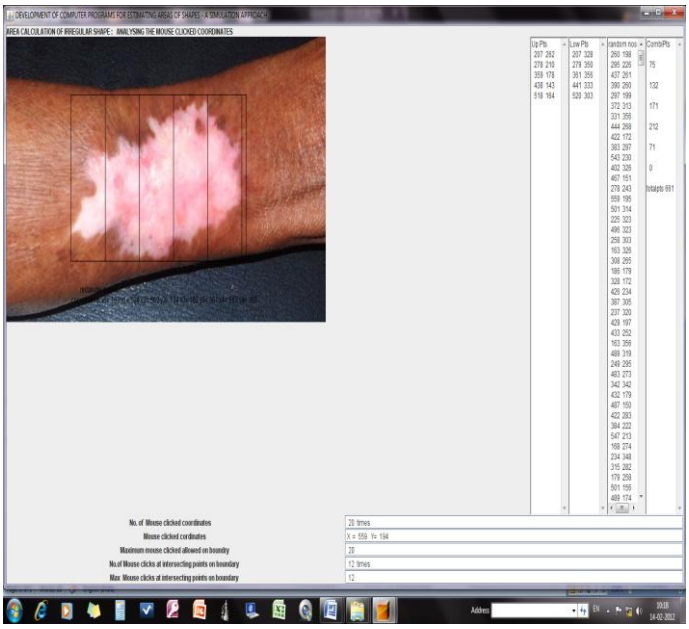


Fig (6.2)

Coordinates (x, y) of each strip :

Strip 1	Strip 2	Strip 3	*Strip 4*
177 326 177 308	238 331 238 216	320 369 320 204	402 343 402 153

Strip 5	Strip 6
481 323 481 134	559 284 559 194

Table (6.3)

Midpoint on each strip:

Upper boundary Midpoints
207 262 278 210 359 178 438 143 518 164
Lower Boundary Midpoints
207 328 279 350 361 356 441 333 520 303

Table (6.4)

Points lying in each strip:

Strip 1	Strip 2	Strip 3
77	152	189

Strip 4	Strip 5	Strip 6
194	86	0
Total points lying in the vitiligo patch = 699 **Estimated Area ratio = 699/1200 = 0.5825**		

Table (6.5)

VII. PROCEDURE FOR REFINING ESTIMATED AREAS

When the given shape is regular shape an alternative mathematical procedure is available to verify the accuracy of the estimated area. This can be done only for regular shape. For an irregular shape(like image of vitiligo patch), since the actual area is unknown one has to develop procedures to refine the estimates obtained. This can be done in two ways:

7.1 Refine Procedure-I (RP-I)

Estimates can be refined by increasing the number Of strips that the rectangle is divided [vide step -3 in section-5] Number of Strips 'k' can be 6, 11, 16, 21.As the number of strips are increasing the boundary points also increases and estimated area of the irregular shape will e more accurate.

NO. OF STRIPS	INTERVAL	NO. OF POINTS
6	80	77 153 189 194 86 0
11	40	19 40 61 85 81 90 105 114 66 47 0

16	26	9 31 24 46 51 60 75 70 72 49 60 76 40 22 3 0
21	18	4 26 35 35 27 47 39 31 45 45 59 43 53 56 43 46 13 17 6 4 3

Table (7.1)

7.2 REFINE PROCEDURE-II (RP-II)

Refining the estimates can also be done by increasing number of pairs of random points 'n' generated

7.2.1 By applying above procedure the following estimates are obtained and comparisons are made for different 'n' generated.

RANDOM NO PAIRS	*NO. OF POINTS FALLING INSIDE*	*RATIO: PTSINSIDE/RAND POINTS*
100	59	**0.59**
300	174	**0.58**
500	291	**0.582**
800	468	**0.585**
1000	589	**0.589**
1100	646	**0.5872**
1200	699	**0.5825**
1300	757	**0.5823**

Table (7.2)

VIII. RESULTS AND DISCUSSIONS

Critically Comparing table 7.1 and table 7.2 one can observe that:

1. By increasing 'k' estimated area is refined.
2. By increasing 'N' f_{in} is increasing and hence estimates are becoming more accurate.
3. Comparing RP-I and RP-II, RP-II is more effective in refining the estimates than RP-I. This is because accuracy is more rapidly obtained as no. Of random number pairs 'N' is increased than the no. Of strips 'k' . This is observed in the above example , as the area estimated remains unchanged.
4. As 'N 'increases the corresponding estimates will converge to limit 'l' where 'l' represents actual area of given irregular shape.
5. This can be clearly verified with the estimates obtained when 'k'= 21 and 'N'= 1300. [vide Tables 7.1,7.2]

XI. FURTHER SCOPE OF THE WORK:

On similar lines one can extend the procedures for the following: Overlapping irregular patches 2.disjoint vitiligo patches 3. Patches extended in two sides in body parts. Few of them are explained in the following figures.

Fig (9.1)

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