

Quantitative analysis of Mouza map image to estimate land area using zooming and Canny edge detection

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ABSTRACT

In Bangladesh, mouza map is used to maintain the record of land measurement, which is a form of interpreting land ownership as well as estimation. Unfortunately, the automatic determination of land is still under development. As a result, land administrators have to encounter multiple hurdles while evaluating any area by employing local civil engineers. Thus, our country needs an automated land estimation system so that it can reduce time, cost and other difficulties which inspired us to develop a system that requires only mouza map image. Once image acquisition is done, we applied the curvature interpolation technique to zoom the map that helps to select any area by the Area Selection Method. The selected area is then segmented by employing the Canny edge detection method. Finally, the area is calculated from the segmented image and extracted features of the selected location. Compared to the field measurement, the system gave the accuracy of 89.8%. Hence, the land administrators will be able to provide the land information to the landowners promptly.

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1. INTRODUCTION

The land is considered as the most valuable property in Bangladesh for general people. But, in the modern era, it is estimated that only about 30% of Bangladesh's population has access to formal or statutory systems to register and protect their land rights [1]. The absence of a well-organized automated digital cadastral system is one of the key reasons for these problems.

Building a system that can handle the growing number of land transactions and measurement is one of the critical challenges currently faced by many land administration offices. To calculate the land area, a large measurement tool and human resources are required to cover every cm of the property, which sometimes become infeasible and costly for the land administrators, as portrayed in Figure 1. Subsequently, in Bangladesh, estimating the land area from a crop field or land is a very tedious and exhausting process. This in turn, worsens the lifestyle of almost 70% of the total population, many of which are poor and vulnerable groups in Bangladesh. This problem motivated us to formulate an automated system for measuring the land area from the cadastral map of a specific location [2, 3].



Figure 1. Manual measurement system of the land

High-resolution satellite pictures are regarded as a source of information to resolve such difficulties in many relevant fields of study. Waterbody analysis [4-6], natural resource management [2], crop monitoring and hazard assessment, urban planning, land cover mapping [7-10], local climate zoning [11], and land area estimation are some of the application areas. In order to meet the growing demand for cadastral information mapping, new data compilation and processing tools are rapidly being developed by geospatial specialists. One such particular research concentrates on the usage of land sheet information acquired from high-resolution asteroid images targets cadastral boundary mapping [12, 13].

Due to a focus on fixed boundary approaches, land administration offices in many developing countries stayed passive for many years in providing efficient services for the citizens. The cadastral surveying methods and corresponding outputs don't fit and respond well to the purposes they are designed for. This process takes time for registration, cost, human potential and/or coverage. Concerning accuracy standards, Dale and McLaughlin [12] described that the focus should be on what is indispensable and adequate for the efficiency level for the region, not what is technically possible.

Accordingly, the challenge of the research is to find out an efficient algorithm to show the actual land area from a cadastral map which is also called mouza map in Bangladesh. The mouza sheet has mouza numbers, i.e. plot numbers indicating a particular location of a region (Thana or Union). We are focusing on creating an automated system to show how much square feet are included in a specific area.

2. LITERATURE REVIEW

Image-based mapping techniques have become very exoteric in recent years. However, the interests of implemented methods are quite different from each other. Some works were executed for only photographic techniques; some worked on retrieving the information from the mouza map; some worked only on boundary mapping. Attard [14] was interested in the use of photogrammetric techniques to inspect the tunnel from the cadastral map. This work predominantly focused on the improvement of automated photogrammetric methods for tunnel inspection. The image processing techniques were also applied to get a better understanding of different tunnel inspection procedures. As described in [15], several projects have been implemented to ordain and exploit the potential of photogrammetric techniques. Benjamin et al. [16] took a project on finding out the snow depth using photogrammetric techniques. They designed an unmanned aircraft system which can map the spatially continuous snow depth. The aircraft system was competent in rendering high-resolution and high-accuracy (<10 cm) estimates of snow depth over a small elevated area. Mapping requirements and practice were the parameters to measure the equipose of the final map.

The photo-map scale coordination and accuracy predominantly depend on the resolution and scale of ethereal photography, the flying height, the base-height ratio and the features of the stereo description and plotting [17]. The selection of the photographic balance based on the mapping scale and contour interval examined by the British air survey companies is given by [18]. When photogrammetric methods are used for boundary mapping, the technical necessities of the final map should be considered. But this depends on how to alleviate the geometric displacements and distortions. On the basis of acquirable accuracy and manner of use, five approaches for photogrammetric mapping are identified by [19]. In the study of [20], the hybrid vectorizing software is developed to enhance the deficiency of the analogue methods and to ensure the accuracy of the mouza maps. The hybrid vectorizing receives a screen-digitizing method as a prototype and makes the procedure automatic to find the intersection of lines with efficiency. Consequently, in the aspect of

the accuracy, there is no dissimilarity between the screen-digitizing method and the hybrid method because the hybrid method is founded on the screen-digitization.

In [21], updating of mouza maps were conducted employing asteroid image, and the changes of ground features were perceived in correlation with satellite image and orthophoto. The mouza maps were evaluated based on findings for effective land management and supervision. The research tried to keep the effectiveness of satellite imagery using GIS for land management and administration in Myanmar.

From home and abroad study, it is clear that most of the study focused mainly on mapping techniques. Thus, we explored the image processing methods to form an automated land estimation system to help our land administration office and general people. Operation of secondary image processing and extraction of quantitative properties have also been taken care off.

3. PROPOSED SYSTEM DESIGN

The system design is prepared based on the distinct image processing methods. These methods include image acquisition through a digital camera, preprocessing, segmentation, and area calculation techniques. The computed area is further compared with the real-world hand inspection information. The system architecture is depicted in Figure 2.

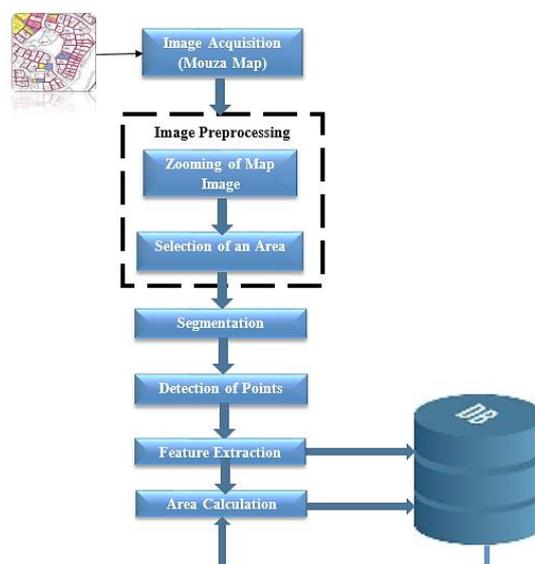


Figure 2. Block diagram of the land measurement system

4. SYSTEM IMPLEMENTATION

4.1. Image acquisition

The first phase of any computer-aided image processing system is the image acquisition stage. After obtaining the images, various methods of preprocessing can be applied to the images to perform different computer vision tasks required. For our application, we collected a mouza map of our study area CHITTAGONG from an AC land office and took some photographs of the parts of the cadastral map with a web camera named Logitech Quick Cam Pro 4000.

4.2. Image preprocessing

Before segmentation and feature extraction, the images of the mouza map are processed. Among several preprocessing, we have selected curvature interpolation technique for Zooming. Then the region is selected from the zoomed image to calculate the area.

4.2.1. Zooming

Zooming technique is used to make an image enlarged so that the pixel colours in the image become more apparent, bright and translucent. Various applications of zooming exist which ranges from zooming through a camera, lens, to zoom an image on the internet etc. Although several are present which does speeding, the most used and effective method for zooming is K-Time Zooming using Interpolation Technique. To enlarge an image, pixels are bounded into the picture. The significant work is the interpolation of the new pixels from

the surrounding original pixels. If we have a small matrix that needs to be zoomed by a factor of 3, and the median of the closest neighbour of three (or four) original pixels are used to interpolate each original pixel. Figure 3 describes an array with interpolation where 00-pixel values are interpolated and then 11-pixel values are interpolated to obtain a zoomed image.

00	01	00	01	00	01	•	01	•	01	•	01
10	11	10	11	10	11	10	11	10	11	10	11
00	01	00	01	00	01	•	01	•	01	•	01
10	11	10	11	10	11	10	11	10	11	10	11
00	01	00	01	00	01	•	01	•	01	•	01
10	11	10	11	10	00	10	11	10	11	10	11
•	01	•	01	•	01	•	□	•	□	•	□
10	□	10	□	10	□	<	□	<	□	≡	□
•	01	•	01	•	01	•	□	•	□	•	□
10	□	10	□	10	□	<	□	<	□	≡	□
•	01	•	01	•	01	•	□	•	□	•	□
10	□	10	□	10	□	<	□	<	□	≡	□

Figure 3. An image array with interpolation

To demonstrate the process, consider augmentation of the image rendered by an array of pixels, the pixel in the i th row and j th column having brightness a_{ij} will be interpolated into the array X_{pq} with p and q taking values 0 or 1, indicating in the same way if above type of interpolation is required. Interpolation of the pixels is as follows:

$$\begin{cases} x_{ij}^{00} = a_{ij} \\ x_{ij}^{11} = \text{MEDIAN} [a_{ij}, a_{i,j+1}, a_{i+1,j}, a_{i+1,j+1}] \\ x_{ij}^{01} = \text{MEDIAN} [a_{ij}, a_{i,j+1}, 0.5 \langle \rangle x_{i-1,j}^{11}, 0.5 \langle \rangle x_{i+1,j}^{11}] \\ x_{ij}^{10} = \text{MEDIAN} [a_{ij}, a_{i,j+1}, 0.5 \langle \rangle x_{i,j-1}^{11}, 0.5 \langle \rangle x_{i,j+1}^{11}] \end{cases} \quad (1)$$

4.2.2. Selection of an area

Area selection has been executed by exploring with mouza number or by clicking the mouse pointer onto the specific location. The mouza numbers range from 1-500 since the regions of the map shows only the areas of Chittagong division.

4.3. Image segmentation and point detection

The process of image segmentation is cutting and adding an image into area or regions that have a strong interrelation with objects using the theory of matrix analysis. The following techniques can achieve segmentation: thresholding, edge-based segmentation and region-based segmentation, and k-means clustering [22]. We have used Canny edge detection to segment our preprocessed image.

4.3.1. Canny edge detector

Canny edge detection procedure calculates the first derivative of a noise reduction technique i.e. Gaussian filter. It then approximates the operator who can optimize the outcome of localization and signal-to-noise ratio [23]. This procedure can be explained with the following notations.

Let $V [i, j]$ denote the image. The result of a twisted image with a Gaussian filter is an array of smoothed data.

$$S[i, j] = G[i, j; \sigma] \times I[i, j] \quad (2)$$

where σ controls the degree of image filtering. $S[i, j]$ is a smoothed array whose gradient can be computed employing the 2×2 difference approximations to generate two arrays $W[i, j]$ and $X[i, j]$ for the x and y partial derivatives.

$$W[i, j] \approx \frac{S[i, j+1] - S[i, j] + S[i+1, j+1] - S[i+1, j]}{2} \quad (3)$$

$$X[i, j] \approx \frac{S[i, j] - S[i+1, j] + S[i, j+1] - S[i+1, j+1]}{2} \quad (4)$$

The finite differences are averaged over the 2 x 2 square so that the x and y partial derivatives are computed at the same point in the image. The standard formulas to compute the magnitude and gradient are:

$$T[i, j] = \sqrt{W[i, j]^2 + X[i, j]^2} \quad (5)$$

$$\theta[i, j] = \arctan(W[i, j], X[i, j]) \quad (6)$$

4.4. Detection of points

After zooming the image of the map, we have picked the location that we want to obtain the area associated with real-world knowledge. The point selection (or pixel selection as Figure 4) refers to the point inside the scope of the object graph. The object rectangle or triangle indicates the smallest outer rectangle or triangle or polygon of the graphic object. The boundaries of any visual target can be calculated from its rectangular or triangular feature points. Precisely, it is to determine whether the distance between the mouse position and the boundaries of given recognition is accurate or not. In our system, the recognition accuracy varies. There are several methods to select graphic objects [24].

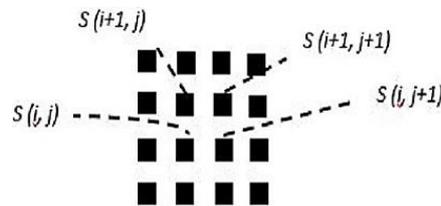


Figure 4. Pixel selection for edge detection

To estimate the area, we have to detect all the points that intersect with each other. To identify the intersecting points, we have applied the sweep line algorithm. If we want to select mouza number 22, it will detect the points as Figure 5. In order to detect point A, the first detected point, the image is scanned from starting coordinate towards its width. After finishing the first row, started from the second row. Since from the observation, the grey level values are not more than 100, the grey level value 100 is taken as a standard for edge pixels. Andrew's algorithm divides the convex hull into the upper and the lower hull. Usually, these meet at the endpoints, but if more than one points have maximal (or minimal) Y coordinate, then they are linked by a horizontal line segment. The upper hull can be constructed similarly, and in fact, can be formed in the same loop.

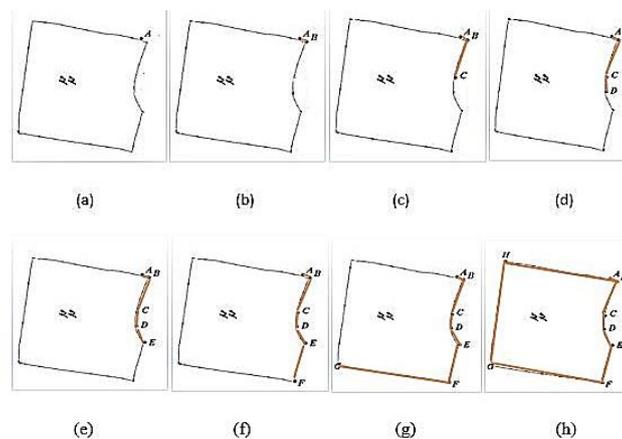


Figure 5. Steps of detecting the intersect points of the selected area; (a) detection of point (DP) A, (b) detection of point (DP) B, (c) detection of point (DP) C, (d) detection of point (DP) D, (e) detection of point (DP) E, (f) detection of point (DP) F, (g) detection of point (DP) G, and (h) detection of point (DP) H

4.4.1. Extracting the features

After applying Canny edge detection algorithm. Several points have been detected based on the shape of the selected area (SA) to find out the possible features. For the example map of Figure 6, the extracted point features of SA are A, B, C, D, E, F, G, H, i.e. eight points are extracted here and the extracted line features are A-B, B-C, C-D, D-E, E-F, F-G, G-H and H-A. Since the selected area (SA) has eight sides, and it produces a polygon, we have to divide it into several triangles. Three distance features will come from AB, BC, CA joining triangle ΔABC ; three distance features will come from AC, CH, HA joining triangle ΔACH ; three distance features will come from CD, DH, HC joining triangle ΔCDH ; three distance features will come from DE, EH, HD joining triangle ΔDEH ; three distance features will come from EF, FH, HE joining triangle ΔEFH ; and three distance features will come from HF, FG, GH joining triangle ΔGFH . Finally, combining all the approaches, we get thirteen distance features AB, BC, CD, DE, EF, FG, GH, HA, HF, FH, HD, CH and AC.

4.4.2. Calculation of the area

After employing the feature extraction, we have measured the area of that specific location. Firstly, we have extracted the pixel coordinates of each detected points and then measured the distance of points that create lines as LF. The distance is calculated utilizing the formula of Euclidean distance. Finally, the area of triangles has been computed to get the whole area of a particular location. To do that, we extracted the pixel coordinates of the PFs and measured the distances of LFs. The result of area calculation of Figure 6 is shown in Table 1.

After calculating the line distance, we have measured the area of all triangles generated from the LFs as triangle features (TFs) and finally sum up all the area of TFs to obtain the region of the whole selected realm. The calculation is shown in Table 2. The area in $pixel^2$ is then converted to m^2 and Acres to get the actual location area. For conversion, we have applied FOV (Field of View) technique as [25] which gave a result of $1\ pixel^2=0.01024\ m^2$. Thus, the final area of selected region of Figure 6 is $53.986 * 0.01024=0.5525m^2$.



Figure 6. Process of feature extraction; (a) detection of points as point features (PF) A, B, C, D, E, F, G, H, (b) detection of line features (DF) as AB, BC, CD, DE, EF, FG, GH, HA, CH, DH, EH, FH, AC

Table 1. PF and LF measures

PF	X	Y	LF	PF Coordinates	Distance Measure $\sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$
A	7	12	AB	(7.12), (8.11)	$\sqrt{(7 - 12)^2 + (8 - 11)^2} = 1.414$
B	8	11	BC	(8.11), (7.8)	$\sqrt{(8 - 11)^2 + (7 - 8)^2} = 3.162$
C	7	8	CD	(7.8), (6.7)	$\sqrt{(7 - 8)^2 + (6 - 7)^2} = 1.414$
D	6	7	DE	(6.7), (7.5)	$\sqrt{(6 - 7)^2 + (7 - 5)^2} = 2.236$
E	7	5	EF	(7.5), (6.2)	$\sqrt{(7 - 5)^2 + (6 - 2)^2} = 3.162$
F	6	2	FG	(6.2), (1.3)	$\sqrt{(6 - 2)^2 + (1 - 3)^2} = 5.099$
G	1	3	GH	(1.3), (3.13)	$\sqrt{(1 - 3)^2 + (3 - 13)^2} = 10.198$
H	3	13	HA	(3.13), (7.12)	$\sqrt{(3 - 13)^2 + (7 - 12)^2} = 9.84$
			AC	(7.12), (7.8)	$\sqrt{(7 - 12)^2 + (7 - 8)^2} = 4.000$
			HC	(3.13), (7.8)	$\sqrt{(3 - 13)^2 + (7 - 8)^2} = 6.403$
			HD	(3.13), (6.7)	$\sqrt{(3 - 13)^2 + (6 - 7)^2} = 6.708$
			HE	(3.13), (7.5)	$\sqrt{(3 - 13)^2 + (7 - 5)^2} = 8.944$
			HF	(3.13), (6.2)	$\sqrt{(3 - 13)^2 + (6 - 2)^2} = 11.401$

Table 2. Coordinates of PF

Triangle features (TFs)	Associated LFs	Area (Pixel ²) $\sqrt{s * (s - a) * (s - b) * (s - c)}$
ΔABC	AB, BC, AC	1.99
ΔACH	AC, HA, HC	8.004
ΔCDH	CD, HD, HC	4.499
ΔDEH	DE, HE, HD	3.492
ΔEFH	EF, HE, HF	10.002
ΔGFH	HG, HF, GH	25.999
Total		53.986

5. EXPERIMENTAL RESULT

5.1. Sample collection and zooming

As described in section 4.1, we collected the mouza map from Chittagong AC land office. Thus, a part of the mouza map is shown in Figure 7 (a). Figure 7 (b) depicts the enlarged image of the selected part of the mouza map after applying the zooming technique. The mouza numbers become understandable once zooming is applied.

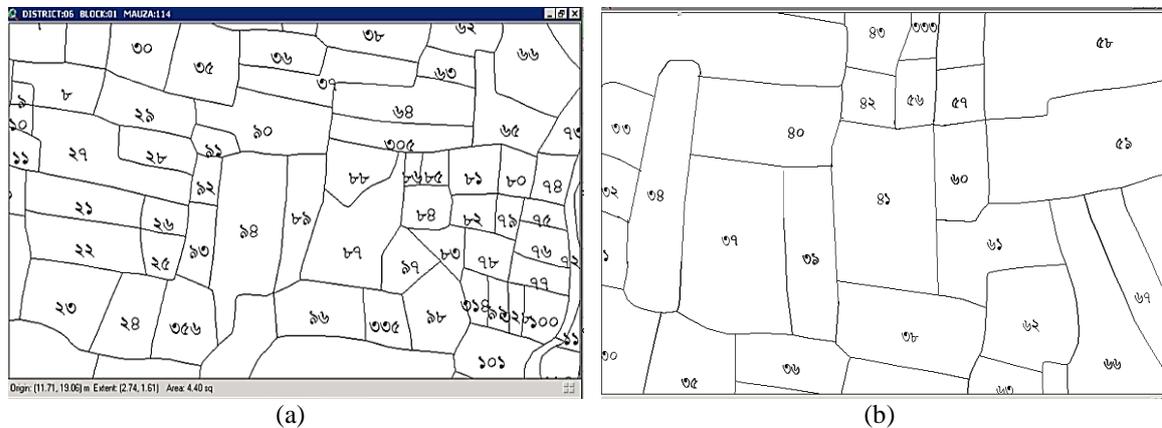


Figure 7. (a) Collected image (b) zoomed image

5.2. Area selection and calculation

Area selection was a very tedious task to accomplish. The area selection method works efficiently for the locations where the region lines are clear and sharp. Conversely, the process doesn't work correctly if the sides are vague and obsolete. Still, the success rate of area selection is almost 92.4% of the collected map. Some of the area selection samples are depicted in Figure 8.

From Figure 8, it can be seen that the selection of mouza number 38 and 39 conflicts to each other since the vertical line is not clear. Thus, the area selection accuracy of our system is shown in section 5.3. Lastly, area calculation has been implemented on all the mouza numbers that are present in the mouza map (as described in section 4.4.2). Some of our results are shown in Table 3.

Table 3. Results in m² and acres

Mouza No	Area (m ²)	Area (Acres)
90	1025.056	0.254
34	65.141	0.016
102	3012.022	0.744
42	5112.245	1.263
43	10023.033	2.476
60	1102.311	0.272
49	967.112	0.238
271	20345.523	5.027
398	501.089	0.12
450	12045.675	2.976
365	5490.098	1.356
498	200.149	0.049

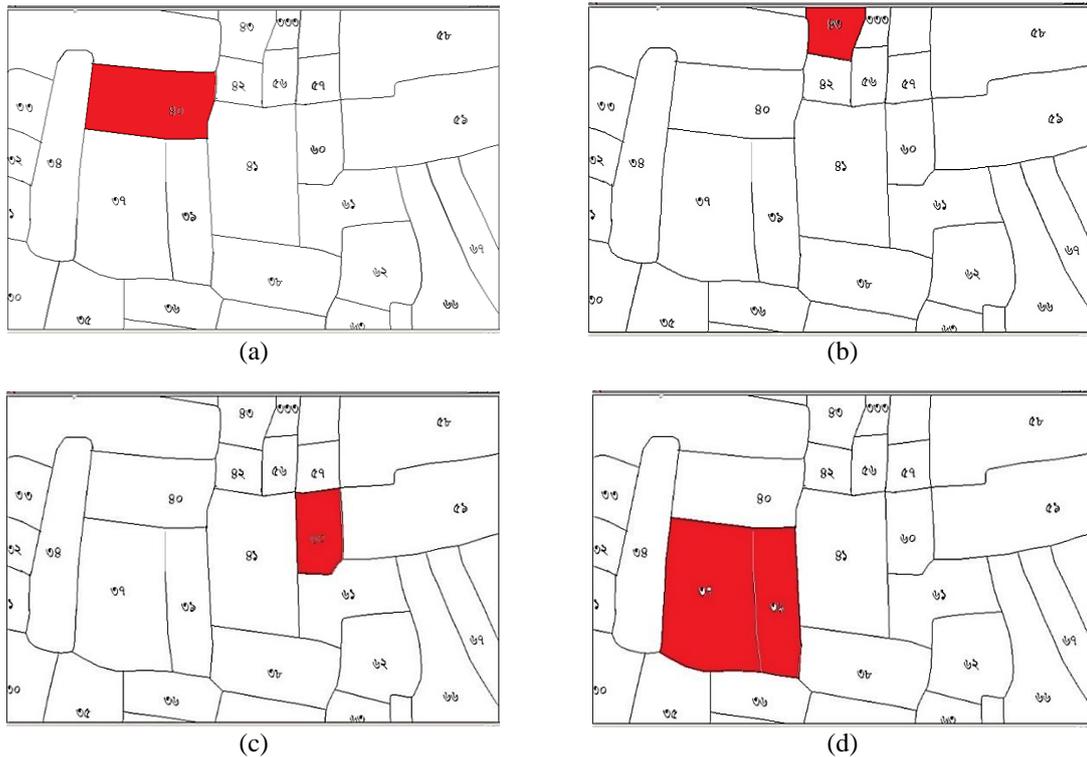


Figure 8. Area selection and point detection images; (a) selection of mouza number 40, (b) selection of mouza number 43, (c) selection of mouza number 60, (d) inefficiency of selection of mouza number 38

5.3. Performance analysis

The collected mouza map has 500 regions on it. As a result, the system calculated all the areas of the map. Four hundred sixty-two regions were selected correctly, and the system was unable to select the rest 38 locations. After calculating the area of these locations, we have compared all the computed area with real-world information that we got from AC land office. We noticed that our system could measure 415 locations properly from the correctly selected areas and area of 47 locations slightly varies from the actual measurement. Since the system performance depends on the area selection, we have divided performance evaluation in two categories as follows, and system performance evaluation is shown in Table 4.

- Area selection accuracy
- Area measurement accuracy

Table 4. System accuracy measure

	Correct		Incorrect		Accuracy
	Selection	Calculation	Selection	Calculation	
For area selection accuracy	462	472	38	38	$\frac{485}{500} \times 100 = 92.4\%$
For area calculation accuracy	462	415	47	85	$\frac{450}{485} \times 100 = 89.8\%$

6. CONCLUSION

The manuscript performed a generalized technique to show the area of a particular location from the mouza map. To do that, we have applied several image processing manoeuvrings such as Canny edge detection, curvature interpolation technique, etc. and finally computed the area of a location. Here, the efficiency of the system has been calibrated by considering both the hand inspection and automated system. Our design has excellent performance with 89.8%. Although the accuracy is quite competent, the system can be improved by completely digitalizing the mouza maps and developing a more accurate area selection method. RS (Revisional Survey) and Khatian numbers can be extracted from the image to make searching and calculation of area furthermore efficient.

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