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Image Processing of Topographical Map for Geomatic Survey

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ABSTRACT –

Image processing is a fast growing application in the field of Artificial Intelligence. It is widely used in medical, geomatic, automotive and other fields involving recognition, matching, authentication and data abstraction from images or a video as a frame of images. The work presented focuses on Geomatic survey of a Topographical Map. The proposed framework deals with colour separation , image outline and text detection, followed by shape matching by computing fourier descriptors helping in segmentation of map's features. This helps in recognition of these texts and symbols. The report focuses on **Edge detection** which is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Some edge **detection algorithms** include Sobel, Canny, **fuzzy logic** methods and their combinations as well like ICWFL, Sobel–Zernike moments operator.

Index Terms- colour separation, image outlining, Shape Matching, Topography, Shape recognition, shape analysis, outline detection, template matching, RGB

1. Introduction.

Topographical maps are crucial in the dynamic world of geomatics and land surveying, providing vital data for a wide range of applications ranging from urban planning to environmental management. Traditional data collecting and processing procedures, on the other hand, are generally time-consuming and labor-intensive. This research study investigates the integration of cutting-edge image processing techniques in geomatic surveying, with a specific focus on topographical maps, in order to address these problems and harness the potential of technological breakthroughs. This study intends to improve the precision and efficiency of data extraction from topographical maps using digital image processing, revolutionising the geomatic surveying process. The article provides essential principles, approaches, algorithms, and technologies that allow for simplified workflows, decreased errors, and more informed decision-making in a wide range of practical applications. Through case studies and examples, this research demonstrates the real-world impact of merging geomatics with image processing, ultimately ushering in a new era of precision and automation in topographical data acquisition and analysis, benefiting professionals across numerous industries that rely on topographical information for their projects and decision-making processes.

2. Literature Survey

2.1 Summary of Literature Review

L. Heutte, T. Paquet, J.V. Moreau, Y. Lecourtier, C. Olivier, [1] proposed a solution towards the use of several feature extractors with more complex structures of classification. The set of features (either statistical or structural) describing a pattern must be constrained to map the feature vector. This mapping consists in a parameterization of each feature, i.e., defining numerical parameters for each feature.

K. Deb, A. Pratap, S. Agarwal and T. Meyarivan, [2] proposes a method for ion of abstract regions in a map. The process is subdivided into two steps. First, regional candidates are selected based on an evaluation of neighbourhood relations. Then, objects which consist of a hierarchical combination of single objects are recognized with a grammar-based compiler approach. In sketch interpretation the main focus is more on segmentation, classification and labelling, whereas in map interpretation the focus is more on the following tasks, like segmentation or data mining. Some objects have a very typical unique appearance, like churches. Complex objects can also be interpreted with model-based approaches.

Weindrow, Venkataraman, C. Judice and J. Wilder [3] proposes an approach that is based on a grammatical description of objects. The model is represented with grammatical rules in PROLOG (Logic Programming Language). The inputs are geometrical primitives (lines and text elements) which are grouped together by interpreting the grammatical rules.

Kumawat, Anchal & Panda, Sucheta. [4] describes a feature-based image registration (FBIR) method in combination with an improved version of canny with fuzzy logic for accurate detection of edges. The major contributions of the present work are summarised in three steps. In the first step, a restoration-based enhancement algorithm is proposed to get a fine image from a distorted noisy image. In the second step, two versions of input images are registered using a modified FBIR approach. In the third step, to overcome the drawback of canny edge detection algorithm, each step of the algorithm is modified.

Qu Ying-Dong, Cui Cheng-Song, Chen San-Ben, Li Jin-Quan[5] proposes about a new edge detection approach combining Zernike moments operator with Sobel operator. There are two steps in this detection: First, the Sobel operator is used to identify all potential edge sites; next, the Zernike moments operator is applied to precisely relocate the edge from the Sobel operator-identified points. Using Zernike moments theory, two masks—one real and one complex—are derived in the second step, and a novel edge point criterion—the magnitude of the complex mask—has been established. Testing of this novel detection method reveals the advantages of excellent subpixel precision as compared to Zernike moments operator and a 79% more efficient runtime.

Yadav, Navdeep & Singh, Vijander & Rani, Asha & Goyal, Sonal. [6] proposes a more effective edge detection method based on hyper smoothing function. It locates the edges of noisy and blurry images without duplicating them and to integrate such edges into meaningful object boundaries. As a result, the local binary pattern is given a logarithmic hyper-smoothing function, resulting in the improved hyperfunction based local binary pattern (IHLBP) algorithm. The USC-SIPL and BSDS databases are used to evaluate the IHLBP algorithm on artificial images, radiography images, and real-world photos. For comparison analysis, the Canny and Sobel approaches, the hyperlocal binary pattern (HLBP), the improved local binary pattern (ILBP), and others are also utilised.

González, Claudia & Melin, Patricia & Castillo, Oscar. [7] proposes a brand-new universal type-2 fuzzy logic edge detection approach for colour format photos. To create a powerful edge detection approach, the suggested algorithm combines the methodology based on picture gradients with general type-2 fuzzy logic theory. We approximate general type-2 fuzzy inference systems with the -planes method. In order to demonstrate the benefits of using the fuzzy edge detection strategy on colour photos compared to grayscale format images and when the images are tainted by noise, the edge detection method is evaluated on a database of colour photographs. This study compares the proposed edge detection algorithm with other edge detection methods, such as those based on type-1 and interval type-2 fuzzy systems. The proposed technique is based on general type-2 fuzzy logic. Because it can deal with the inherent uncertainty in this scenario, edge detection based on a general type-2 fuzzy system beats the alternatives, according to simulation results.

Chiang, Yao-Yi & Leyk, Stefan & Knoblock, Craig. (2014). A Survey of Digital Map Processing Techniques. ACM Computing Surveys. 47. 10.1145/2557423- [8] discusses several methods for processing digital maps. It describes how edge detection algorithms operate and their underlying The idea behind edge detection techniques is to use local filtering operators to identify discontinuities, or abrupt changes in colour values, by detecting contrasts in colour values between regions. It distinguishes among extraction and recognition of singular map, composite, linear features. Edge detection techniques for image outlining is the topic useful here.

Latecki, L. J., Megalooikonomou, V., Wang, Q., & Yu, D. (2007). An elastic partial shape matching technique. Pattern Recognition, 40(11), 3069–3080.- [9] An elastic partial shape matching technique: Transform shapes into sequences and utilise an algorithm that determines a subsequence of a target sequence that best matches a query. this paper demonstrates the benefits of MVM subsequence matching applied to partial shape matching. The reported experiments show that this method is able to perform partial shape matching effectively and significantly outperforms DTW and LCSS in terms of retrieval accuracy. By mapping the problem of elastic matching of sequences to the problem of finding the cheapest path in a DAG, we provide an efficient algorithm to compute the shape similarity. It results in automatically skipping outliers that are present in the target sequence. It also computes the translation or scale of corresponding values that minimises the statistical variance of dissimilarities of corresponding elements.

W. Wang, Q. Lai, H. Fu, J. Shen, H. Ling and R. Yang, "Salient Object Detection in the Deep Learning Era: An In-Depth Survey," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 44, no. 6, pp. 3239-3259, 1 June 2022, doi: 10.1109/TPAMI.2021.3051099. [10] - To measure the similarity between the shapes and exploit it for object recognition The states algorithm was tested on real images of text, in which binarization was performed followed by boundary extraction. By removing the effects of jitter noise, grey scale images are identified.

C. Gotsman, "On graph partitioning, spectral analysis, and digital mesh processing," 2003 Shape Modeling International., 2003, pp. 165-171, doi: 10.1109/SMI.2003.1199613-[11] .This paper describes shape matching and object recognition using shape context. Then Solve the correspondence problem between two shapes. Use the correspondence to estimate an aligning transform and compute the distance between two shapes as the sum of matching errors between corresponding points, together with the term "measuring the magnitude of the aligning transformation."

H. Sundar, D. Silver, N. Gagvani and S. Dickinson, "Skeleton based shape matching and retrieval," 2003 Shape Modeling International., 2003, pp. 130-139, doi: 10.1109/SMI.2003.1199609.- [12] The algorithm was tested on real images of text, in which binarization was performed followed by boundary extraction. Since the sample points are drawn randomly and independently from the two shapes, there is inevitably jitter noise in the output of the matching algorithm, which finds correspondences between these two sets of sample points. However, when the transformation between the shapes is estimated as a regularised thin plate spline, the effect of this jitter is smoothed away.

X. Bai, C. Rao and X. Wang, "Shape Vocabulary: A Robust and Efficient Shape Representation for Shape Matching," in IEEE Transactions on Image Processing, vol. 23, no. 9, pp. 3935-3949, Sept. 2014, doi: 10.1109/TIP.2014.2336542.- [13] A Robust and Efficient Shape Representation for Shape Matching: In this paper, a learning-based shape descriptor for shape matching is demonstrated. Formulated in a bag-of-words-like framework, the proposed method summarises the local features extracted from certain shapes to generate an integrated representation. The proposed shape descriptor is validated on several benchmark data sets for evaluating 2D and 3D shape matching algorithms, and it is observed that the investigated shape descriptor maintains superior discriminative power as well as high time efficiency. In this paper, a learning-based shape descriptor for shape matching is investigated. The proposed method summarises the local features extracted from certain shapes to generate an integrated representation under a BoW-like framework. It contributes to the speed-up of shape matching.

Martin Drauschke, Wolfgang Förstner (auth.), Rudolf Mester, Michael Felsberg (eds.) Series: Lecture Notes in Computer Science 6835 Image processing, computer vision, pattern recognition, and graphics.-[14] This paper discusses measuring similarity between the shapes and exploiting it for object recognition. The algorithm was tested on real images of text in which binarization was performed followed by boundary extraction. Featured based method, Brightness based method, Bipartite Graph matching, Modeling Transformation. Grayscale images were identified by eliminating the effect of jitter noise.

The comparison of the discussed approaches are presented in table 1.

Literature	**Pros**	**Cons**
Salient Object Detection in the Deep Learning Era: An In-Depth Survey	Grey scale images identified by eliminating affect of jitter noise	Experiment is performed on limited data.
Shape matching and object recognition using shape context.	Transformation between the shapes is estimated as a regularised thin plate spline, the effect of this jitter is smoothed away.	Outliers cannot be skipped.
Skeleton Based Shape Matching and Retrieval	The computation of the skeleton is fast and is proportional to the number of voxels in the model.	Jitter noise reduces the accuracy of model.

1. All the papers have RGB as their Common base and primary colour with either GSM or ethernet as their bin server connecting technology. Every paper has used different segmentation for calculating fill level of bin and few others among them have IR for object detection and load cell for weight calculation. Only three of them have implemented scheduling for different segmentation processes.
2. In the Image Outlining Process using Edge Detection Techniques, most of them had singleton operators present and not fusion of 2 or more operators. This led to their results lagging behind in either one feature or another. One of the papers stated a fusion of 2 operators: IFCWL, having Canny as well as Fuzzy Logic Method, but it required image extraction and image matching, proving it difficult to operate, thus improvement.
3. The purpose of Shape Matching technique is to find imperfect instances of objects within a certain class of shapes through a voting procedure. This voting procedure is carried out in parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. In the automated analysis of digital images, a common sub-problem often arises in detecting simple shapes, such as straight lines, circles, or ellipses. In many cases, an edge detector can be used as a pre-processing stage to obtain image points or image pixels that are on the desired curve in the image space. Due to imperfections in either the image data or the edge detector, however, there may be missing points or pixels on the desired curves as well as spatial deviations between the ideal line, circle, or ellipse and the noisy edge points as they are obtained from the edge detector. For these reasons, it is often nontrivial to group the extracted edge features into an appropriate set of lines, circles, or ellipses. The purpose of the Hough transform is to address this problem by making it possible to perform groupings of edge points into object candidates by performing an explicit voting procedure over a set of parameterized image objects.

3. Proposed System

3.1. Introduction

As colour segmentation is an emerging field in digital image processing in some cases it becomes necessary to find the total number of colours from the original image. It is very useful in many medical applications, some of which are detecting brain tumours and cancerous cells. In the proposed method each colour present in an image is shown separately. The procedure of calculating total number of colours from an image is very helpful in quantization of image.

After studying the applicable domains where the image outlining for symbol segmentation of maps will be used, The system would comprise of image outlining by edge detection technique. We will use a softcopy of a topographical map from The Survey of India for this. This image, after getting colour graded, will be used for image outlining, where the BGR image will be converted to grayscale image and will be applied to the Canny + Sobel (X+Y) operator function giving us the output. We will be using python and openCV library to carry out the process.

3.2. Existing Architecture/ Flow Diagram:

The Entire Image Processing Process will have the following flow diagram

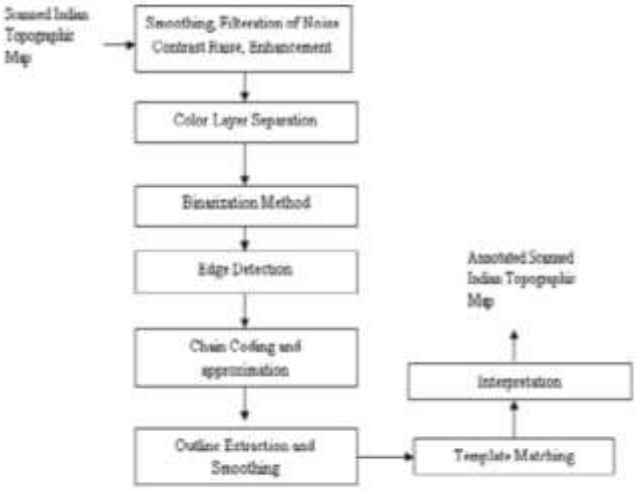

Fig. [3] Image Processing Architecture

1. **Colour Segmentation Process**

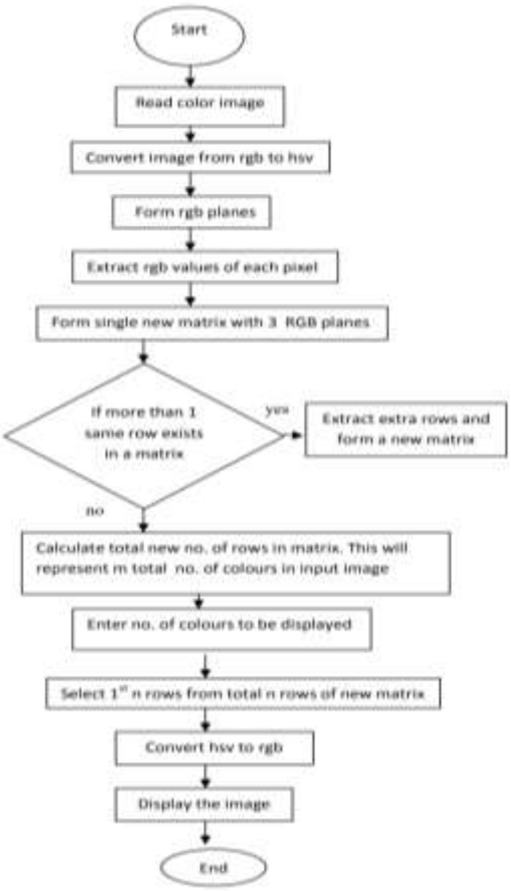

Fig [4] Colour Segmentation Process

2. Image Outlining Process

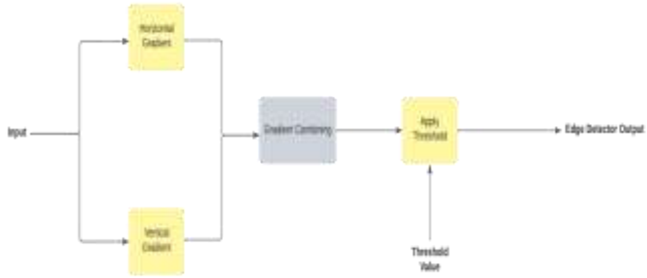

Fig. [5] Image Outlining Process

3.3. Techniques Used :

1. For Colour Segmentation:

The first step in processing the map image is to isolate the contour lines from other map components. To accomplish this, Fig. 1. Original map image one can leverage the previously mentioned monochromaticity of contour lines to segment the original image by colour. As is suggested by most previous research [1],

[2], the RGB colour space is not ideal for this segmentation, due to being perceptually non-uniform. It is therefore proposed that the HSV colour space be used during image segmentation because of its improved uniformity while being easily invertible to RGB.

2. For Image Outlining:

Canny Operator + (Sobel X + Sobel Y) operator

is proposed.

Canny Edge Detection is a popular edge detection algorithm. It is a multi-stage technique. It provides the result as shown in the Figure [5].

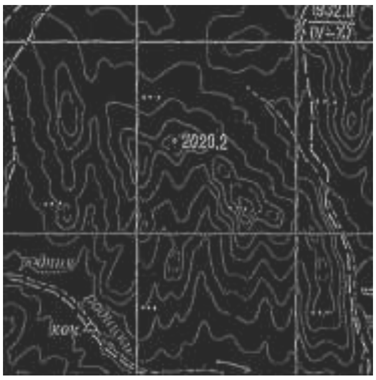

Fig.[6] Result from Canny Operator + (Sobel X + Sobel Y) operator

3. For Shape Detection

Shape detection is an important process to identify the different elements in topographical maps. Using numbers of contour lines the topographical elements such as mountain, hills, valleys can be detected. Using distance between the contour lines slope, height etc of the respective elements can be detected.

Hough transformer is a popular algorithm to detect the shapes like lines, circles, rectangle, square etc But if the signal is discontinued it produces many coefficients of large magnitude because it localises in frequency domain only which results in noise and the accuracy gets affected. This problem can be solved by wavelet transformer since the wavelet transformer localises in time and frequency domain hence if the signal is discontinued it produces less significant coefficient with less magnitude which results in elimination of jitter noise and hence accuracy gets enhanced.

3.4. Improvement from Existing to Proposed Technique :

Table 1:Improvement through proposed system in Edge Detection

Existing System	Drawbacks	Improvement in Proposed System
Laplacian	Outlines are very thin and light, thus features of light BGR intensities after conversion to grayscale won't be identifiable.	The lines are thick, hence identifiable.
Sobel X, Sobel Y & Sobel (X+Y)	It is sensitive to noise, hence degrades as the magnitude of the edges decreases.	The Fusion with canny makes it resistant to noise, hence outline doesn't degrade.
Canny	Grayscale intensity grading doesn't happen, thus texts aren't clearly identifiable .	Sobel Operator improves the grading, hence improves visibility of the texts .

4. Results

4.1 Test Setup:

The setup for the test is a scanned image in RGB format with:

Exposure: 20-30 %

Brilliance: 01-10 %

Contrast: -5 to +5 %

4.2 Pseudo Code

1. Image Outlining:

#import the dependencies

import cv2

import numpy as np

import image

convert RGB to Grayscale image

Performing the edge detection technique(s)

Fuse Canny, Sobel X and Sobel Y techniques

cv2.imshow('sobel(x+y) + canny', sobelxy_canny)

Add wait key to lag the output from 100ms

2. Shape Matching:

Compute features for reference shape

ref_centroid = compute_centroid(ref_shape)

ref_bbox = compute_bounding_box(ref_shape)

ref_histogram=compute_edge_orientation_histogram(ref_shape)

Compute features for input shape

input_centroid = compute_centroid(input_shape)

input_bbox = compute_bounding_box(input_shape)

input_histogram=compute_edge_orientation_histogram(input_shape)

```
# Compute similarity score between features

centroid_distance=euclidean_distance(ref_centroid, input_centroid)

bbox_distance=euclidean_distance(ref_bbox, input_bbox)

histogram_distance=euclidean_distance(ref_histogram, input_histogram)

# Combine distances using weighted sum

score = w1 * centroid_distance + w2 * bbox_distance + w3 * histogram_distance
```

4.3 Test Results

1. Colour Segmentation

2. Image Outlining

Input:

Output:

5. Conclusion & Future Work:

5.1 Conclusion

This research paper underscores the substantial potential of image processing in the realm of geomatic surveying, with a specific focus on the analysis of topographical maps. The integration of advanced image processing techniques, encompassing color segmentation, image outlining, and shape matching, emerges as a promising avenue to significantly enhance the precision and efficiency of data extraction from these intricate maps. Topographical maps play an indispensable role in a diverse range of applications, and the need for improved data collection and processing techniques is evident. By combining the power of artificial intelligence with geomatic surveying, this research offers a path to streamline workflows, reduce errors, and empower professionals across various industries that rely on topographical information for their projects and decision-making processes. As the field continues to evolve, further research can be directed toward database integration and the refinement of topographical element detection accuracy. Ultimately, this research paves the way for a new era of geomatic surveying, marked by increased efficiency and precision, and promises to significantly benefit professionals in their endeavors.

5.2 Future Work

This system is proposed keeping in mind the need for creating an all-in system for identification of natural and man-made features on a map, and providing information on their economic features like demography, industries present for ease of setting up communities, or industrial belts or forecasting future problems to take necessary precautions.

This can be done by inclusion of several kinds of databases available mainly in the gazettes, or present in the databases of the government agencies

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