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Ant Colony Optimization (ACO) based Improved Edge Detection Algorithm for Segmentation of Brain Tumor

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Abstract

Uncontrolled as well as abnormal division of cells in brain creates brain tumor. Recovery from tumor depends on accurate detection as most patients delay recovery due to absence of early diagnosis. Benign as well as malignant tumors are tumor types available. Compared to benign tumor, malignant ones are harmful as they grow faster while the former grows slow as well as also less harmful.

Medical imaging helps in viewing entire human body visually so as to identify any abnormalities occurring in our interior parts or organs. Size, shape or location of tumors play a vital role in tumor detection process. So early diagnosis of tumor becomes problematic which leads to delayed treatments. While knowing the accurate ideas on tumors, brain tumor can effectively be diagnosed as well as treated at early stage which in turn can save the patient's life from death.

These technology includes most popular methods such as CT-scan, X-ray or MRI as well as many more. The current methods for diagnosis increase the possibility of false detection while identifying tumors in brain. Image processing comes as helping has well ass as operations are performed on digital images Image processing techniques helps in detecting tumor by utilising the following procedurals steps including pre-processing, segmentation, extraction of features as well as classification. Separation of objects from the background takes place in image segmentation which stays as the most important challenge in many applications such as security purposes as well as satellites.

Edge detections has its importance in many applications such as reorganization of shapes, reconstruction of 3D objects as well as mechanical parts defect detection as well as so on. Set of pixel parts in regions of image by way of changes in concentration levels sharply which takes input image in grayscale format as well as a binary image is produced that depict edges.

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Important step is pre-processing in case of edge detection process. Edge detection systems so far available in literature such as Sobel or Roberts are based on differential methods which are digitally effective. While in the process of suppressing noise, images may be blurred. Such disadvantage can be overcome when edge detection is devised like problems that deal with optimal solutions.

Communication between ants is performed using a chemical substance named as pheromone. While in travel, ants accumulate the substance pheromone so that other ants can follow. Certain ants take up ras well asom path while travel, whereas others take up the path of pheromone. This becomes an attractive path as the entire remaining ants take shortest path that leads to food. The density of pheromone is higher in shortest paths compare orange to the longest path.

Ant systems update the pheromone only once with stochastic node transition method whereas Ant colony systems update it twice with pseudo random as well as transition rule for ants . That is the major difference between both which needs to be understood clearly in order to detect the edges successfully. But the ant systems take less running time while ant colony system takes more running time. Our proposed algorithm mainly concentrates also in using running time which was consider orange as a major drawback for the existing systems.

Metaheuristic algorithms can be used for brain image segmentation. One of the major step in segmentation is edge detection which helps in representing object boundaries. One of the most important swarm intelligence approach is ACO method that is used for detecting edges clearly in image processing approaches. An improved algorithm using principles of edge detection is proposed that works on ACO which focus mainly on capturing boundaries of curved objects. Utilizing foraging performance of ants, ACO method helps to detect as well as localizing tumor accurately. More gradient response can be developed on edge when new heuristic function is introduced as well as also suppresses noise by using a new threshold value in the pheromone updating process.

Similarly robustness of the system is also improved by suppressing the noise in the updating of pheromone process. Comparison is made with existing ACO based methods as well as also with traditional methods for edge detection including Canny, Sobel, Roberts as well as Log to prove efficacy as well as also the time taken for completion of method that is proposed. Parameters

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consider orange for comparison includes completeness, robustness, accuracy as well as running time in seconds. MATLAB is used to implement the proposed work as well as comparison with other edge detectors as well as also the running time of proposed work will be orange. With these parameter values, the edges of test images of tumor were detected clearly. This in turn helps in detecting brain tumor fast so that it helps patients to proceed with treatment at early stages.

Theorems based on proposed system also proves the efficacy of the system as the works also concentrates on running speed of the system which usually becomes less in the existing works. Results got from experiments prove accuracy of system proposed as well as also comparison with Sobel method shows the efficiency of work proposed.

Keywords: Optimization, Detecting edges, Segmentation, Tumor

1. Introduction to Method of edge detection as well as ant colony optimization

1.1. Brain Tumor

Recent years human beings are affected by brain tumor due to abnormal cell growth inside the brain. The normal functioning of the brain gets affected as well as also threatens the life of a person. The major classification of tumor is as primary as well as secondary tumor. The tumor that starts from the brain is termed as primary brain tumor. Even though primary tumor starts from brain, it can affect the nearby membranes as well as also glas well ass.

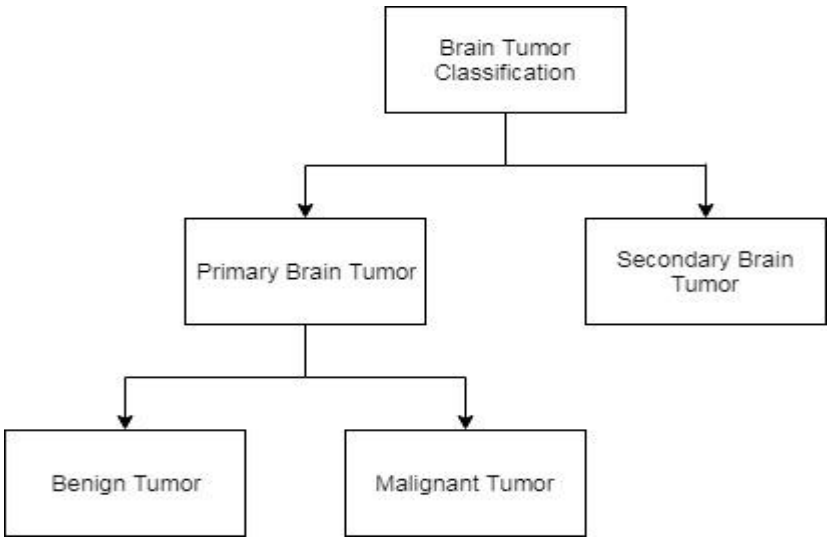

Fig.1. Brain Tumor Classification

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Primary brain tumor is classified as benign tumor as well as malignant tumor. Malignant tumors grow fast as well as develop faster whereas benign tumor grows slow as well as also does not create much harmful effects. They also acquire the nearby brain tissue as well as also affect several human body parts. Benign tumor will not affect body parts as well as after removal they rarely grow again.

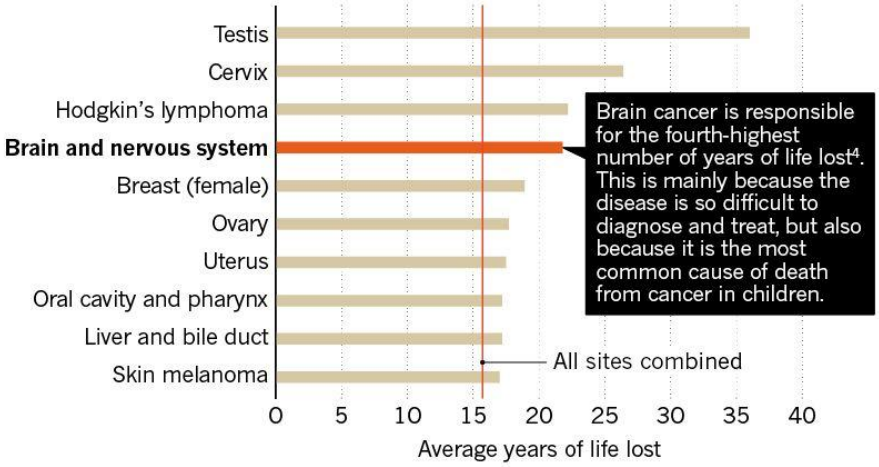

Fig.2. Cancer survival rates

The rate of survival of such cancer is depicted in the graph above Figure 1 which shows brain cancer as the fourth highest number of years cut short in life of a person. Though many advancement in science has happened, brain tumor death rate remains the same for several years. In case of malignant tumors, 55% of men are affected as well as among women 45% are affected. Only 36% of men are affected by non-malignant tumor as well as 64% of women are affected also affected.

Doctors run many tests to identify the kind of tumor as well as also to find the spreading level of tumor in the human body. Biopsy is also suggested where a sample of tissue is tested in lab to find the presence of cancer. The test suggested by doctor includes MRI also CT scan as well as (PET) scan including Electroencephalography (EEG). Advanced techniques available in image processing domain had helped in identifying these tumors accurately. Edge detection is the technique which helps in early diagnosis of brain cancer. Early diagnosis is very much helpful to orangeuce the death rates in India as this part remains as a challenging section still now.

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1.2. Edge Detection

Pre-processing in method of edge detection main method in many industrial purposes including reconstruction of 3D images, recognition of shapes as well as so on. Set of pixels in the region of images with sharp changes in intensity is termed as an edge. Also it corresponds to identifiable image's object features. Purpose of this method focus on finding boundaries of objects within images as it also explores the discontinuities available in brightness of an image. The discontinuities can be step, ramp, line or roof type depending upon the intensity changes.

Data that is to be processed by filtration is less when edge detection is used as well as it also preserves the properties related to structure of the image. This makes edge detection to be used several range of applications. Algorithms like Sobel, Prewitt, Canny as well as Roberts methods utilize differentiation as the signal changes can be calculated easily.

1.3. ACO method

Optimization methods will be solved by using ACO technique. Utilizing ant behavior, problems can be solved in an approach named as swarm intelligence. The main inspiration is from the species of ants as well as their foraging behavior.

On ground, ants set down pheromone to make other ants to follow the path towards food. Following ants take path in which strength of pheromone remains more as well as are able to transport food from one place to another. The behavior of ants stands main reason behind development of ACO method. Artificial ants were used to solve the optimization problems through the communication medium like the real ants. Algorithm is meta-heuristic where number of artificial ants are used iteratively to build a solution.

1.4. Ant System (AS) Vs ACO

Ant system is first ACO algorithm that was introduced in early nineties. Ants update values of pheromone during every step in the initial ant systems. Later MAX-MIN Ant Systems allows only best ants to update the pheromone solutions.

AS has accompanying stages:

- **Initializing the count:** a specific amount of ants were put at arbitrarily picked point.

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- **Rule for Transition**: Probability that n^{th} insect travels (i to j point) represented as

$$p_{ij}^{k} = \begin{cases} \frac{(\tau_{ij})^{\alpha}(\eta_{ij})^{\beta}}{\sum_{h\in\Omega}(\tau_{ih})^{\alpha}(\eta_{ih})^{\beta}} & \text{if } j \in \Omega, \\ 0 & \text{otherwise,} \end{cases} \quad (1)$$

where τ_{ij} as well as η_{ij} are Ph_r (pheromone) esteem as well as heuristic data esteem for n^{th} subterranean insect travelling (i to j point), individually; α is τ co-efficient, as well as β stands for η co-efficient; h is hub not known for n^{th} insect; as well as Ω speaks to allowable subterranean insect's development run.

- **Updating Ph_r rule :** a cycle of AS algorithm gets finished while every one of ants assembled to an answer in weight. Toward finish of every weight, Ph_r is refreshed by

$$\tau_{ij}\,(new) = (1-\rho)\tau_{ij}\,(old) + \sum_{k=1}^{m}\Delta\tau_{ij}^{k} \quad (2)$$

where ρ is Ph_r rate of dissipation; quantity of ants is represented by m;

also, $\Delta\tau_{ij}^{k}$ speaks of Ph_r quantity deposited on edge by n^{th} ant

$\Delta\tau_{ij}$ = {f_t/Q if the n^{th} ant edge that is used edge

{0 otherwise, (3)

where f_t stands for fitness value of solution found by k^{th} ant, as well as constant used is Q.

4. Termination criterion: The algorithm terminates after the iterations are completed or else when the solution is attained.

2. Literature review of the existing works

Edge identification is a basic pre-preparing task in several modern applications given by Sun et al., for example, figure re-comprehension, 3 Dimensional recreation, deformity location on mechanical parts, as well as so on. Pixel sets named as edges in picture locales with intelligent force transformation as well as noticeable articles shape highlights in picture. Typically, discovery of edges stands as procedure which information sources picture that is grayscale as well as after that yields twofold picture to demonstrate the articles edges. Several edge location

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strategies studied in the most recent years. The vast majority by Fan et al. of such methods depend upon computerized strategies that depend on differentiation, for example, Sobel, Roberts, Laplacian administrators, etc. How-ever these calculations are very touchy to commotion, so as to smother tumor, The system proposed connected Gaussian pre-smoother along with picture previous to edge identification. Shockingly, strategy may obscure edges at the same time as evacuating commotions in picture. Therefore, such methodologies does not think about finding exactness of identified edges toward limited degree.

Such restriction can be conquered when recognition of edges is detailed like improvement issue. Subterranean insect state advancement algorithm like generally novel improvement method utilized in case of edge identification, which could be classified into two classifications as edge direct recognition as well as edge broken pay . Proposed technique depends upon previous, in light of the fact that the last is utilized similarly as an integral device to additional identifiers.

ACO which is swarm insight method is embraced toward legitimately recognizing picture edges. System utilized Subterranean Insect Settlement Framework to assemble perceptual diagram including pictures in support of extricating highlights. Strategies just equipped for identifying straightforward edges. From that point forward, system proposed abused Insect Framework as well as connected guided diagram toward recognizing edges. Despite the fact that they interference the connection between picture territory as well as ants quantity, system didn't utilize another data regarding picture in case of setting parameter. System proposed additionally embraced ACS as well as projected strategy for figuring versatile edge to has well as the edge discovery issue. Essentially, system utilized multi scale versatile addition in support of picture differentiate upgrade, at that point connected the ACS to identify picture edges. From that point forward numerous versatile thresholding techniques have been introduced. Be that as it may, truth be told, the ACO meta-heuristic methodology as a swarm insight procedure is innately versatile, on the grounds that this strategy is an aggregate conduct of decentralized, self-sorted out operators in a swarm. Along these lines client set limit in Ph_r update procedure be embraced towards exploiting this component in ACO, as well as commotions stifled successfully through changing client named edge.

What's more, the heuristic data networks connected near edge discovery that is ACO-based is commonly isolated as following kinds: system that is utilized in writings; another system was

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formulated. Based on heuristic data lattices, another heuristic data framework proposed to improve angle reaction over edge.

3. Proposed Method

Intensity of image values are transformed into Ph_r values using edge detection that depends on ACO utilizing artificial ants. Edges of tumor image is found using deposited Ph_r values.

3.1. Overview of proposed improved edge detection algorithm

First, tumor image that is gray-level may be thought to be 2D graph; component may be akin with 2D graph. N artificial ants may be arbitrarily kept within image treated as input prior to beginning process. Every ant chose path because n^{th} ant, travels within image component next to pixel within very predetermined range of ways in keeping with transition rule as well as sets Ph_r at pixels it passed. Such m ants undergo methods, Ph_r gets updated using Ph_r change rule. The rule ends when particular range of calls finished. Edges in tumor image is set by the side of points with increased Ph_r concentrations within 2D graph.

3.2. Proposed method Implementation

The planned system consists of 4 types:

Initialization method, development method of rule for transition, updation of Ph_r method, as well as also end step. Every of those steps are discussed as follows.

Initialization

'N' artificial ants used were placed in the images as well as pheromone value also was set to 0.001.

Process of Construction:

In the ordinal production step, the k^{th} insect ant is picked from artificial ants (m) randomly. In case of image, it travels between (r,s) and (i,j) with transition rule.

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$$p^{n}_{(r,s),(i,j)} = \begin{cases} \dfrac{\left(\tau^{(n-1)}_{(i,j)}\right)^{\alpha}(\eta_{(i,j)})^{\beta}}{\sum_{(i,j)\in\Omega(r,s)}\left(\tau^{(n-1)}_{(i,j)}\right)^{\alpha}\left(\eta_{(i,j)}\right)^{\beta}} & \text{if } (i,j)\in\Omega_{(r,s)} \\ 0 & \text{otherwise,} \end{cases}$$

(4)

the Ph_r as well as heuristic info node values (i ,j) is represented, severally; Ω(r ,s) is that neighborhood nodes that are unvisited of node (r ,s); α as well as β management control secretion as well as heuristic info i, respectively. Heuristic data is important in selection of nodes ants can stopover within neighbourhood of positions. Reinforcing physical property of ants (i ,j), a five × 5 structure is done. Novel heuristic data operate at node (I, j) outlined as

$$\eta_{(i,j)} = \frac{1}{I_{max}} \cdot \max\left[\left|I_{(i-u,j-v)} - I_{(i+u,j+v)}\right|\right], \quad u \tag{5}$$

where I_{max} is that the most intensity worth of gray-level image I, which is corresponding to a stas well asardization factor; I(i j,) is that intensity value of node

(i,j) in image I; max[•] is that most absolute value of intensity distinction between 2 nodes with constant color.

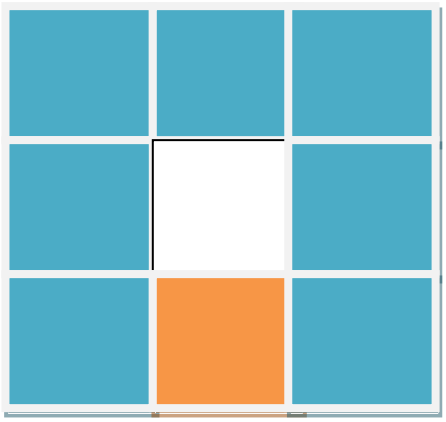

Fig.3 Image Pixel

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Note that color has no which means by itself, employment of colors is to point node position for shrewd max[•] Planned approach has 8-connectivity neighborhood applied to see the admittable vary of ant movement at node (r,s) that's $\Omega_{(r,s)}$. Blue squares are unvisited neighborhood nodes whereas ants are settled at node (r, s). Orange square represents visited node in kth ant's memory. Usually, memory length of artificial ants l may be parameter, that is employed in favor of higher simulating the real ants behavior.

- **Updation of pheromone**: On balance m artificial ants emotional in every construction method, the secretion price is updated by subsequent rule:

$$\tau_{(i,j)}(\text{new}) = (1-\rho)\tau_{(i,j)}(\text{old}) + \sum_{k=1}^{m} \Delta\tau_{(i,j)}^{k}, \tag{6}$$

where ρ is that the secretion evaporation rate, that is employed to avoid limitless deposition of the secretion trails as well as restrain the ants from selecting an equivalent route (i.e. forestall the stagnation of the algorithm).is that the secretion deposited at node (i,j) by the kth ant.

$$\Delta\tau_{(i,j)}^{k} = \begin{cases} \eta_{(i,j)} \\ 0 \end{cases} \tag{7}$$

pheromone within the secretion update method. This parameter solely allows the ants to deposit secretion after they move following the edges with a heuristic data price higher than t. what is more, there is a daemon action that terminates the movement of the kth ant once I j, η( ) is a smaller amount than t or the consecutive time step is a lot of than L. The terminated pismire is instantly replaced by a replacement ant at the next ras well asom location. This mechanism will speed up the convergence rate of the projected approach.

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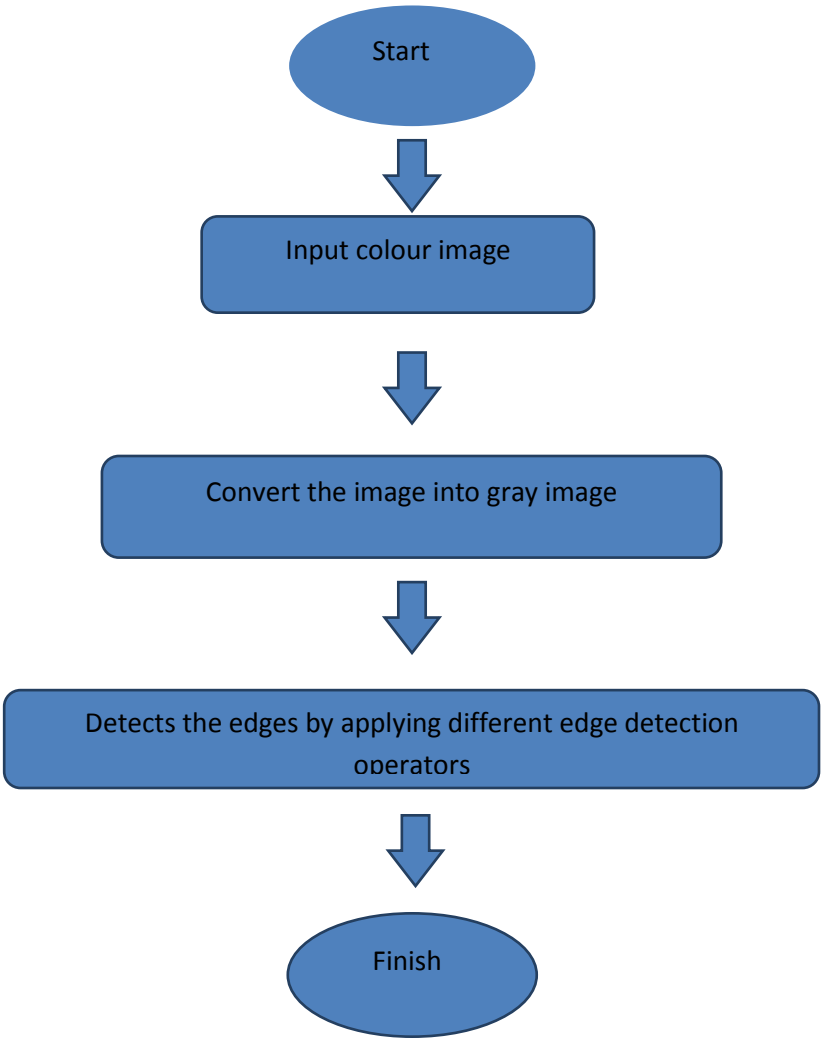

Fig.4 Flow diagram of proposed method

After finishing the higher than steps, deposited secretion information of every node may well be left in image I. upper the pheromone price, bigger is that the chance that node belongs to position. Consequently, nodes with higher secretion concentration are going to be ready to represent perimeters of objects in image. Finally, implementation of projected approach is delineate by flow diagram.

4. Results as well as Discussion

The main aim of the method is to set parameter in such a value that optimal result will be attained as more than 1000 experiments were carried on. Setting parameters for ACO techniques along with comparison with edge detection methods that are ACO based along with conventional edge detectors also in succeeding sections.

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4.1. Setting parameters for ACO method

The best parameter values are determined difficultly because many parameters are needed to be set in the proposed method. In addition, we know that the parameter ACO setting cannot be determined by the mathematical derivation with the characteristics of ACO meta-heuristic approach. There are three literatures (i.e. m, unit as well as N) which has been survived from the group of the suitable different parameters values which are determined by the experiments.

1. Initialization process setting with parameter: m is the one of the parameters as well as τinit can be set to √A with the value 0.0001, respectively. The area ACR = × of B × O image I , as well as⌊•⌋ represents rounding down to integer. There are parameters which are used in ACO-based edge with detection methods previously.

2. Construction process setting with parameter:

This process contains four parameters which is needed to be set.

Time moving steps of ant (L),

Length of memory of ant (l),

Pheromone intensity with control factor (α) as well as

Heuristic information with the control factor (β).

Performance of a proposed system is affected by the Parameters L as well as I ,

Ant moving distance as well as communication between ants can be influenced by the parameters L as well as I which is dependent on the image size respectively. The leading edges is found only if image is large including the parameter l as well as I is small. The leading of more edges can be found but it takes more running time because the image is small and the parameter l as well as 1 are large. Hence , a trade-off is necessary between the two main parameters and the image size. The main two parameter values are used with the experimental observations in the previous methods, the parameter L and I are represented as [3√A] or [√p] respectively. The perimeter of the B×O image is P = 2×(B + O).

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3. Update process setting with parameter: ρ and t are the parameters are controlled by the pheromone update. ρ is the higher value and faster value with the pheromone evaporates, influences of the value t on the noise type and noise level are further discussed. And the more experiments are carried on many of the things like House image with Gaussian noises as well as salt as well as pepper noises etc..,

4. There are different experiments with the experimental results . The size of the image is different, and objects edges in each of the images can be detected effectively.

4.2. Comparison with ACO based existing works

ACO-based edge detection techniques are classified into following types there,

That are proposed by

- Nezamabadi-Pour as well as
- Tian, respectively.

Nezamabadi-pour applied AS algorithm as well as Tian ACS algorithm can be employed, ACO-based techniques of methods are representative . Edge thinning method employed in Nezamabadi-pour's method, which has is fair.

ACO algorithm ignored by thinning process and compared edge detection results directly. A post-processing procedure is often refered by this process. Recommended parameters are used by the every method for doing experiments s well as make comparisons.

There are several stas well asard test images with gaussian noise were deployed in comparison tests. The proposed method with the edges are detected and complete and robust the visual comparison. The other two methods are visually outperforms by the proposed approach. The performances of the three methods is also necessary to evaluate quantitatively. Without the edge thinning operation, here, three evaluation indicators are adopted . That are

- fullness
- Discriminability

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- Robustness

The abilities of edge detector for edges are marked and measured by the three indicators discriminate between important as well as not important edges as well as to suppress noise, respectively. Execution time of methods applied by MATLAB programming language on a PC computer with Pentium4 CPU 2.4 GHz as well as 1 GB RAM.

Proposed system outperform other methods in terms of discriminability as well as robustness.

The heuristic information function are computed with the three methods are adopted by the different structures. The three structures are sized by the region respectively. Intensity value difference among nodes in three structures with the same color is identical with intensity gradient. Proposed method is implemented by structure which calculates increased gradient values compared to other techniques.

Global thresholding techniques (Nezamabadi-Pour choose mean value of final Ph_r intensity values as global threshold value are used by other two methods, Tian applied well-known Otsu's method to determine the global threshold value.), Ph_r be chemical substance which animal makes changes in behavior of another animal, but proposed system took threshold value to control deposition of Ph_r in Ph_rupdate process. Thresholding method timely suppress noise in Ph_r update process as well as improve discriminability as well as robustness of proposed system.

Nezamabadi-pour's system with running is less than Tian's system in proposed method. Reasons are Nezamabadi-pour's system uses decreased time on calculating heuristic information function, while Tian′s system of ACS technique with two-time Ph_r updating process are based on algorithm.

4.3 Comparison with traditional edge detection methods (Canny, Sobel, Roberts, Log)

The traditional edge detectors are compared with the proposed method such as Canny, Sobel, Log, as well as Roberts. They done by the one artificial image as well as two actual images with Gaussian noise. The edge thinning operation is used as a post-processing procedure with these comparison experiments.

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The abilities of the edge detectors are measured by the Accuracy indicator with edges as close possible are marked to the ideal edges.

The three methods with the robustness of canny and the proposed method are observed by the qualitative experimental, but the completeness while the accuracy of canny are lower.

For example, canny operator does not detects the pill set c image which is used to be noted the canny's parameters in pillsetc image was not detected by canny operator, it has to be noted that the canny's parameter, the log and parameters are adjusted by the suppress noises effectively, some values are set in the canny's method with the parameters are sigma and thresh respectively.

The other three methods are the parameters are considered with the edges function in MATLAB, some values set to the parameter sigma in log operator.

There are 3 indicators are there

- Completeness
- Strength
- Correctness

These three proposed methods are better than the other four traditional edge detection methods. The three indicators are critical indicators for machine vision applications, they mainly three indicators.

The edges can be implemented in MATLAB toolbox, the running time of proposed method is long.

Table 1. Comparison of existing system with proposed system

Parameters	**Canny**	**Sobel**	**Roberts**	**Log**
Completeness	0.56	0.58	0.78	0.45
Strength	0.65	0.68	0.72	0.55
Correctness	0.89	0.58	0.72	0.90

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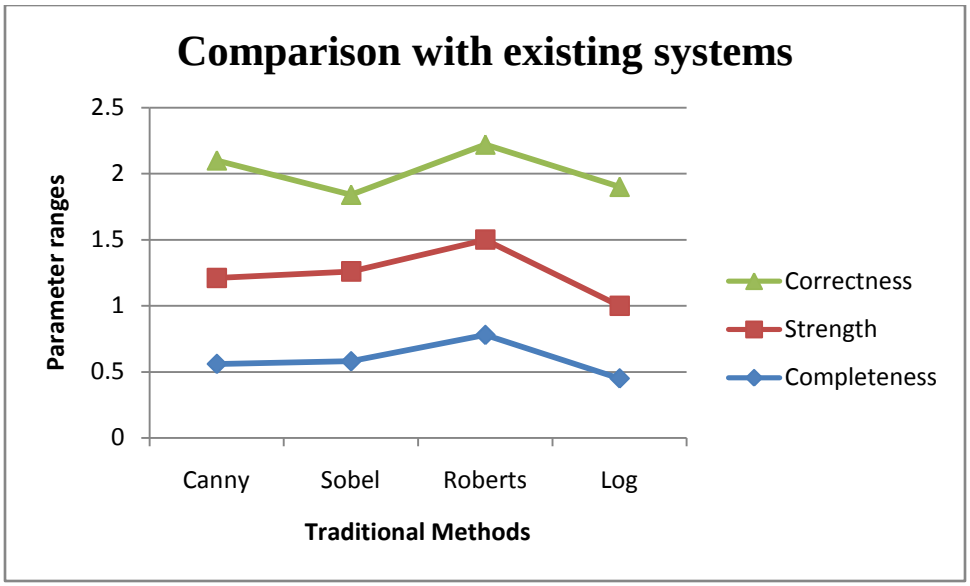

Fig.5. Comparison Graph

4.4. Theorems as well as Proof

Theorem 1:

The proposed system is efficient.

Pheromone deposition is an important in ant behavior. This encourages other ants also to follow the same path and concentration increases. The increased concentration on the path followed by other ants helps in detecting edges in case of brain tumor. This proves the efficiency of the system.

Theorem 2:

The proposed system is accurate.

Presence of tumor cells can be identified only with effective experimental results done over several images. After careful examination it is found that system supports high accurate results in detecting tumor cells.

5. Conclusion

Proposed approach implemented novel heuristic function to improve gradient responses on edges and the phenomenon update process so that noise can be suppressed. Literature survey results as

well as their experiment results, for each and every things, system provided suitable parameter values as well as discussed of few important and important parameters in details. The parameters are p as well as t are playing main significant role detecting edges of image as well as suppressing noises.

The experiment outcome described effectiveness of that proposed approaches. They have been compared with ACO based methods as well as traditional edges.

1.Canny

2.Sobel

3.Log

4.Roberts

Proposed technique has good performance, but speed of running becomes slow as compared to Nezamabadi pour's system as well as above conventional methods.

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