Ant Colony Optimization for 2-D Images

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Abstract

The ant colony optimization is a very powerful technique to find out solutions to combinatorial optimization problems. Ant Colony Optimization is a paradigm for designing net heuristic algorithms for combinatorial optimization problems. The first algorithm which can be classified within this framework was presented in 1991 and, since then, many diverse variants of the basic principle have been reported. The essential trait of ACO algorithms is the combination of a priori information about the structure of a promising solution with a posteriori information about the structure of previously obtained good solutions. The final section of the work presents a 3-d proposition gradually maturing from 2-d and its implementation.

Keywords

Max-Min, Pheromone, edge, pixel, local intensity value, optimization MATLAB, etc.

I. Introduction

In this paper we have implemented the current edge detection technique and implement it in MATLAB. Further, we propose a new 3-d system for the edge detection in the last section of the paper gradually mature from 2-d optimization of the system, which has already been done. In section I and II, we present the technique used so far for edge detection using ant [3,4,7] colony. Section III gives the basic principle and working of detecting edges using ant-colony optimization. Section IV represents 2- d optimization technique and the related output obtained using MATLAB .In section V, we also propose a new 3-d approach for the same. The results are obtained and depicted in the section VI for reference. The following section enlists the steps in optimization of edge information.

II. Ant Colony Optimization

Establishment of matrix (also known as Pheromone [1,2]) is done as first step in the optimization of edges. It represents edge information at each pixel of the image. As the system proceeds, the movement is considered as the function of local intensity value which refers to change in gray value. In this paper we just improves ant system as given by Tian and his colleagues using matlab and proposed 3-d system. This technique is based on natural behavior of the ants. The ants keep on leaving behind themselves a chemical substance called pheromone to help their peers forage. This very behavior of ants is mapped as a technique forming a matrix representing the edge information.

The final step involves finding the net variation in the gray value and marking it as an edge of the image under consideration. This method is used for ant system, the one having the status of one of the first ever algorithms in the optimization of the edge detection and same is used for Max-Min ant [3,4,7] system and then ant colony system.

Actually ACO (Ant Colony Optimization) System proceeds as:

1. Initialize position of the total ants or points
2. Initialize Pheromone [1,2] matrix $P^{(Int)}$
3. For each constructive step let us say n=1:N & for points (ant [3, 4, 7]s) index=1:K
4. Update $P^{(Int)}$ to P(n)
5. Find solution for P(N)

For each constructive step means movement is done according to probability of steps define by probabilistic transition matrix say PTM(n) [8] of M_1 X M_2 size where M_1 & M_2 are nodes in this space. This is the method used so far. The work done in optimization is elaborated in the section III.

III. Working of ACO

The movement from node let us say from node i to j according to probabilistic action rule is defined as:

Step 1: PTM(n) [8] or $P_{i,j}^{(n)} = ({}_{\Gamma i,j}^{(n-1)})\alpha \ (\eta_{i,j})^{\beta} / \sum j \in \Omega_i ({}_{\Gamma i,j}^{(n-1)}) \alpha \ (\eta_{i,j})^{\beta}$

This is applicable if and only if $\sum j \in \Omega_i$

Where the term ${}_{\Gamma i,j}^{(n-1)}$ Pheromone information value, α and β Influence of Pheromone [1-2] and influence of heuristic that is value depend upon previous experience,η i,j is heuritics information and fix for each step,, Ω i Neighborhood of current position.

Step 2: After that the updating of Pheromone [1,2] matrix is done twice, as follow-

(a) For movement of each step or ant [3,4,7] with in each constructive step

${}_{\Gamma i,j}^{(n-1)} = \{(1-D).{}_{\Gamma i,j}^{(n-1)} + D.\Phi_{i,}^{j(k)}$ is for best match

${}_{\Gamma i,j}^{(n-1)}$ Else if so

(b) Second update after all the ants move in each step, swhich is

${}_{\Gamma}^{(n)} = (1-¶).\ {}_{\Gamma}^{(n-1)} + ¶\ {}_{\Gamma}^{(int)}$

Where ¶ is Pheromone [1-2] decay, D is evaporation rate.

IV. ACO for 2-d

So far in the current work, we have discussed 1-d system, the proposed system for 2-d optimization is as:

The assumption is that each pixel is treated as node and ${}_{\Gamma}^{(int)}$ is constant [3,4,7] now the PTM is given as:

Step1: PTM(n) [8] or

$P_{(l,m)(i,j)}^{(n)} = ({}_{\Gamma i,j}^{(n-1)})\alpha \ (\eta_{i,j})^{\beta} / \sum j,j \in \Omega_{(l,m)} ({}_{\Gamma i,j}^{(n-1)})\alpha \ (\eta_{i,j})^{\beta}$

This is applicable if and only if $\sum j \in \Omega$ i

Where the term ${}_{\Gamma i,j}^{(n-1)}$ Pheromone [1-2] information value, α and β Influence of Pheromone and influence of heuristic that is value depend upon previous experience, η i,j is heuritics information and fix for each step, Ω i Neighborhood of current position.

Now the movement is from (l,m) that is node 1 to (i,j) node 2,but in the previous movement is from j to i and to, Ω i

For the system above we here make some assumptions;

As,ηi,j=1/Z(VC)(Ii,j)……..Equation1

Where Z is normalization factor and z starts from 1 to M_1 and from 1 to M_2,, $I_{i,j}$ is intensity value and(V_C $I_{i,j}$) is a function of local group of pixels; that group may be represented by (a square box) and its value depends on variation of image intensity value.

As it is quite clear that the movement is from c to c and from p to p which produces the output for (intensity$_1$ – Intensity at$_{-1}$) and simultaneously from the other corners as well.

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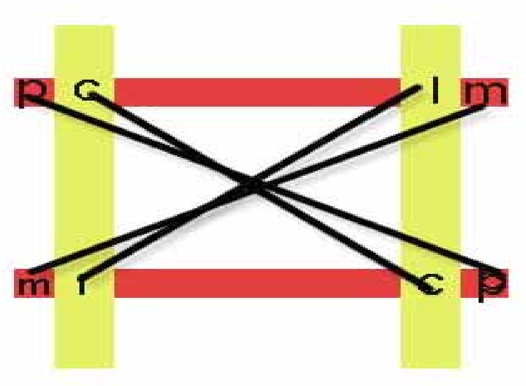


Fig. 1: Movement from c-c and from p-p and m-m

parameter = $(V_C I_{i,j})$ = Function of (Intensity$_2$ - Intensity at$_{-2}$) + (Intensity$_1$ - Intensity at$_{-1}$). This applies for all other corners or edges.
We can use various functions for the parameter $(V_C I_{i,j})$ but here we have used Linear, Squared and Sinusoidal functions. The next issue is to find neighborhood connectivity (Ω). From the fig. 2 it is clear that a pixel can be in either four or eight neighborhood connectivity. For the 3-d system we try to make neighborhood connectivity either 6 or 12, as one each for upper and below of the page, with same functions that is Linear, Squared, Sinusoidal.

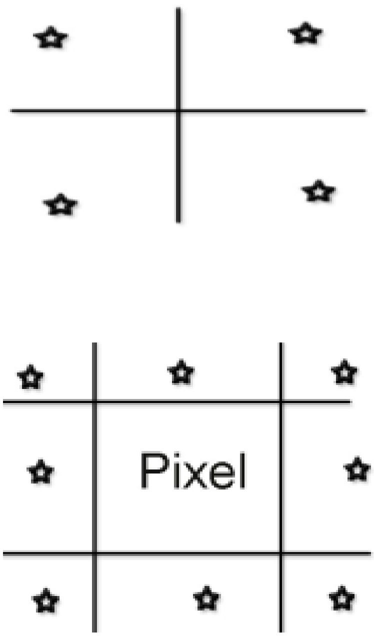


Fig. 2: Four neighborhood connectivity and eight neighborhood

V. Proposed system for 3-d

The updation after movement is as per below:
The parameter $_{\Gamma i,j}$ will retain its value as earlier but $\Phi_{i,j}$ will become equal to $\eta_{i,j}$, This clearly means that it depends on heuristic matrix. The threshold selection as defined for gray level image is histograms based.
Initially T_0(initial threshold) = mean value of Pheromone [1-2] matrix, now Pheromone [1-2] can be divided in two parts one above T_0 i.e T_U and other below T_0 i.e T_B.so

$$\Theta=(T_U+T_B)/2 \qquad \text{Equation 3}$$

$$T_0=\sum_{i,j}^{M_1 M_2} {}_{\Gamma i,j}^{(N)}/M_1M_2 \qquad \text{Equation 4}$$

$$T_U^{(l)}=\sum_{i,j}^{M_1 M_2} P_T^{L}(l)_{\Gamma i,j}^{(N)}/H_T^{L}(l) \qquad \text{Equation 5}$$

$$T_B^{(l)}=\sum_{i,j}^{M_1 M_2} P_T^{U}(l)_{\Gamma i,j}^{(N)}/H_T^{U}(l) \qquad \text{Equation 6}$$

$$P_T^{L}(X)=\begin{cases} X & \text{If } X<=T^{(l)} \\ O & \text{Else if} \end{cases} \qquad \text{Equation 7}$$

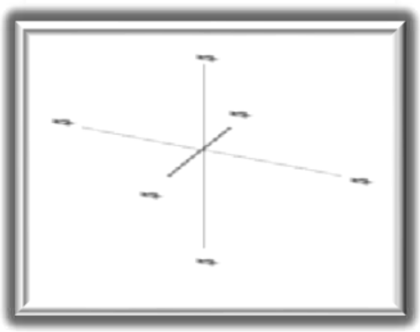
$$H_T^{L}(X)=\begin{cases} 1 & \text{If } X<=T^{(l)} \\ O & \text{Else if} \end{cases} \qquad \text{Equation 8}$$

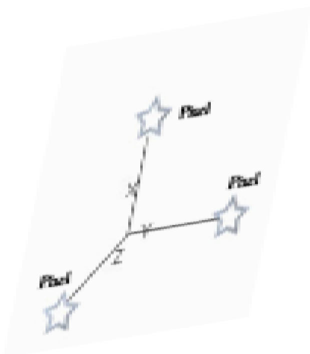
Where $T^{(l)}= (T_U^{(l)}+ T_B^{(l)})/2$,
Steps for final threshold are as below:
1. If { $T^{(l)}$- $T^{(n-1)}$}>0.1 then repeat
2. If edge $E_{i,j}$=1
   Else 0

Where E is Euclidean distance.
Again we here need to find PTM as below,

$$P_{(l,m,z)(i,j,t)}^{(n)} = ({}_{\Gamma i,j\,t}^{(n-1)})\alpha \ (\eta_{i,j\,t})^{\beta} / \sum j,j,t \in \Omega_{(l,m,z)} ({}_{\Gamma i,j\,t}^{(n-1)})\alpha\, (\eta_{i,j\,t})^{\beta}$$

Where the term $_{\Gamma i,j\,t}^{(n-1)}$ Pheromone [1-2] information value, α and β Influence of Pheromone [1-2] and influence of heuristic that is value depend upon previous experience, η i,j,t is heuritics information and fix for each step, Ώ i ,j,t neighborhood of current position.
Now the movement is from (l,m z) that is node 1 to (i,j t) node 2, but in the 1-d movement is from j to i and to, Ώ i ,j,t
For the system above we here make some assumptions;
As $\eta_{i,j\,t=1/Z}\ (V_C)(I_{i,j\,t})$
For the 3-d system we try to make neighborhood connectivity either 6 or 12, as one each for upper and below of the page. With same functions that is Linear, Squared, Sinusoidal (Fig. 3)





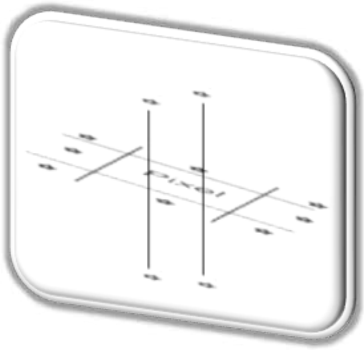


Fig. 3: Six neighborhood connectivity, dimensions and Twelve neighborhoods

The updation after movement is as per below;
The parameter $\Gamma_{i,j\,t}$ will retain its value as earlier but $\Phi_{i,j\,t}$ will become equal to $\eta_{i,j\,t,}$ this clearly means that it depends on heuristic matrix. The threshold selection as defined for gray level image is histograms based.
Initially TO(initial threshold) = mean value of Pheromone [1,2] matrix, now Pheromone[1,2] can be divided in two parts one above T_0 i.e T_U and other below T_0 i.e T_B.so

$\Theta=(T_U+T_{B.})/2$ Equation 3
Rest terms will be same as for 2-d system.
Where $T^{(l)}= (T_U^{(l)}+ T_B^{(l)})/2$,
Steps for final threshold are as below:
1. If { $T^{(l)}- T^{(n-1)}$}>0.1 then repeat
2. If edge $E_{i,j}$=1
   Else 0
Where E is Euclidean [5-6] distance.

VI. Conclusion

We have implemented 2-d approach for edge detection and proposed 3-d approach. The scope of the current work lies in Matlab implementation for the proposed 3-d approach. The critical issues in the above is to fix standards value for Γ, α,η, β, ϵ, Ω etc.

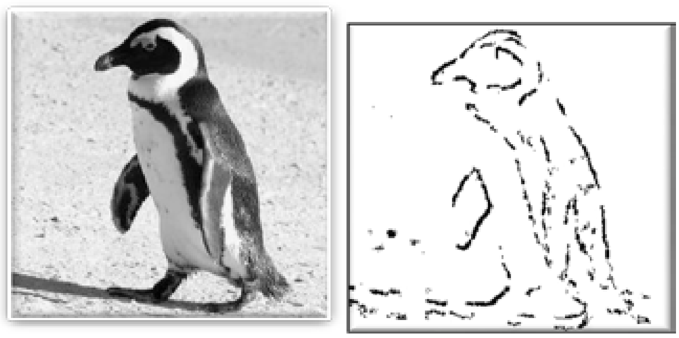


Fig. 4: Input image and output for linear function

The output of the system is clear from fig. 4,We found our result on I-5 Machine with 4 GB Ram in 30 Minutes. The results can vary with different configurations.

Fig. 5: Proposed input image and output for linear function

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