Recognition of 2-D Optical Pattern by using Simulated Annealing Algorithm

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A classical optical correlator cannot give better performance in the recognition process when the input has different scale and orientation with respect to reference image. Correlation performance can be improved using techniques such as Mellin transforms for scale invariance, circular harmonic expansion for rotation-invariance and synthetic discriminant function for scale and rotation invariances. In the present study, a bipolar composite filter (BCF) is design using simulated annealing algorithm. It can be a rotation-invariant or scale invariant or both depending on one's choice. In the present study, it is constructed for out of scale pattern recognition it is noticed that BCF offers high discrimination capability for targets and anti-target patterns.

Keywords: Correlation, Bipolar Composite Filter (BCF), Pattern recognition.

1. INTRODUCTION

Pattern recognition in particular optical pattern recognition plays an important role in the modern era of technology, which finds applications in different field e.g. medical, defence, security and electronic commerce etc. Use of computers for fast processing of data in a variety of applications makes things somewhat secure and easier. But when it comes to handling of huge amount data, fast and efficient algorithms are to be employed for processing optical patterns of objects [1,2]. So there is a requirement for a means to process data more rapidly and accurately. A large section of useful data in various fields is in the form of optical patterns and when optical data are digitized, they constitute huge data base which requires careful handling. This is why the optical pattern retention has become an important field of research in the last 25 years. Images of the objects in the form of photographs which may be of biological bodies, various weapons, etc. are in fact quite common after coming of the digital cameras [3].

Pattern recognition involves the matching of target pattern with the reference pattern based on correlation technique. The correlation technique provides a measure to find out the presence of particular pattern from a large number of reference patterns [4]. Simulating the process in a computer, we can perform the correlation operation computationally. The bipolar composite filter for optical pattern recognition has attracted considerable interest because of their optical efficiency and excellent correlation performance when compared with the conventional optical matched filter (OMF) [5]. The optimization process of BCF for pattern classification with the simulated annealing algorithm corresponds to supervised learning i.e. it trains BCF to give high correlation responses for one class and low correlation for the other [6,7].

2. THEORY

The simulated annealing (SA) algorithm is an iterative algorithm for solving complex optimization problems. The SA algorithm finds the value of the system variable for which the system has a global minimum energy [8]. In a metallurgic annealing process, a piece of metal is heated to a high temperature at which patches within it are quite mobile the global minimum energy or ground state of physical system is reached by cooling the system from high temperature to low temperature. The cooling schedule should be controlled appropriately. If the system is cooled too fast, it can get trapped in metastable states that are local energy minima. If it is cooled too slowly, it takes a long time to reach the final state (global energy minimum) [9].

The SA algorithm simulates such an annealing process by reducing a temperature parameter from an initially high value and perturbing the system variables as the temperature changes. When the system variable u_i is randomly perturbed by Δu_i the energy difference ΔE is calculated:

$$\Delta E = E^{new} - E^{old}$$

where $E^{new} = E(u_i^{old} + \Delta u_i)$ and $E^{old} = E(u_i^{old})$.

If $\Delta E < 0$ then Δu_i is unconditionally accepted. Otherwise, it is conditionally accepted, based on the acceptance probability $P(\Delta E)$

$$P(\Delta E) = 1/\,[1+\exp(\Delta E/T)]$$

where T is the temperature parameter in SA algorithm.

If the perturbation is accepted $u_i = u_i^{old} + \Delta u_i$; If not, $u_i = u_i^{old}$. The process is repeated by randomly perturbing each of the variables and gradually decreasing the temperature T. The temperature should decrease slowly enough so that the system does not get trapped in local energy minima [10,11].

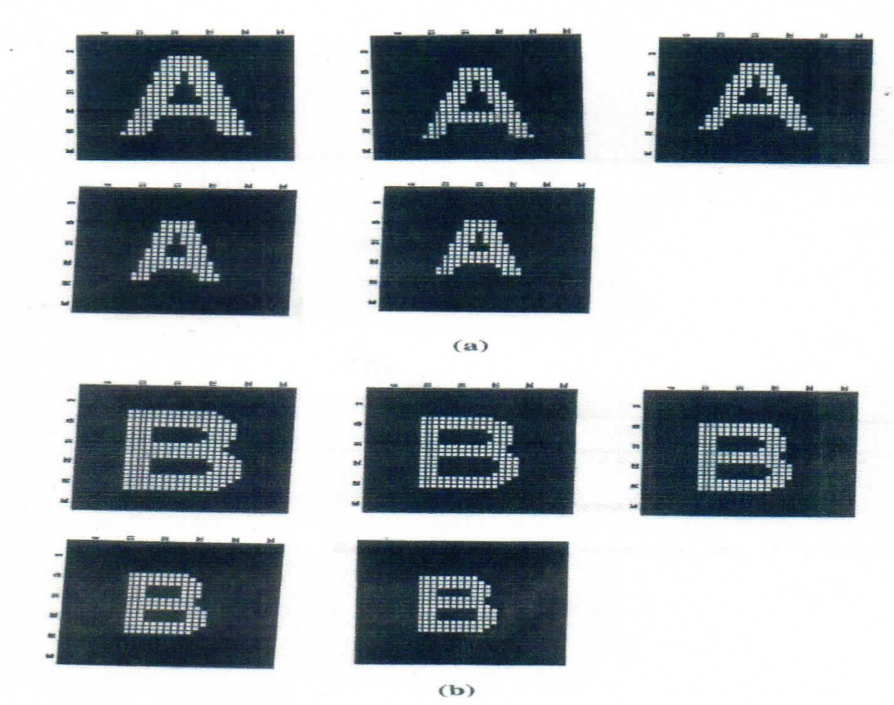

Fig. 1: Two sets of different size training images, each image differs by scale size 2; (a) English alphabet letter A, (b) English alphabet letter B.

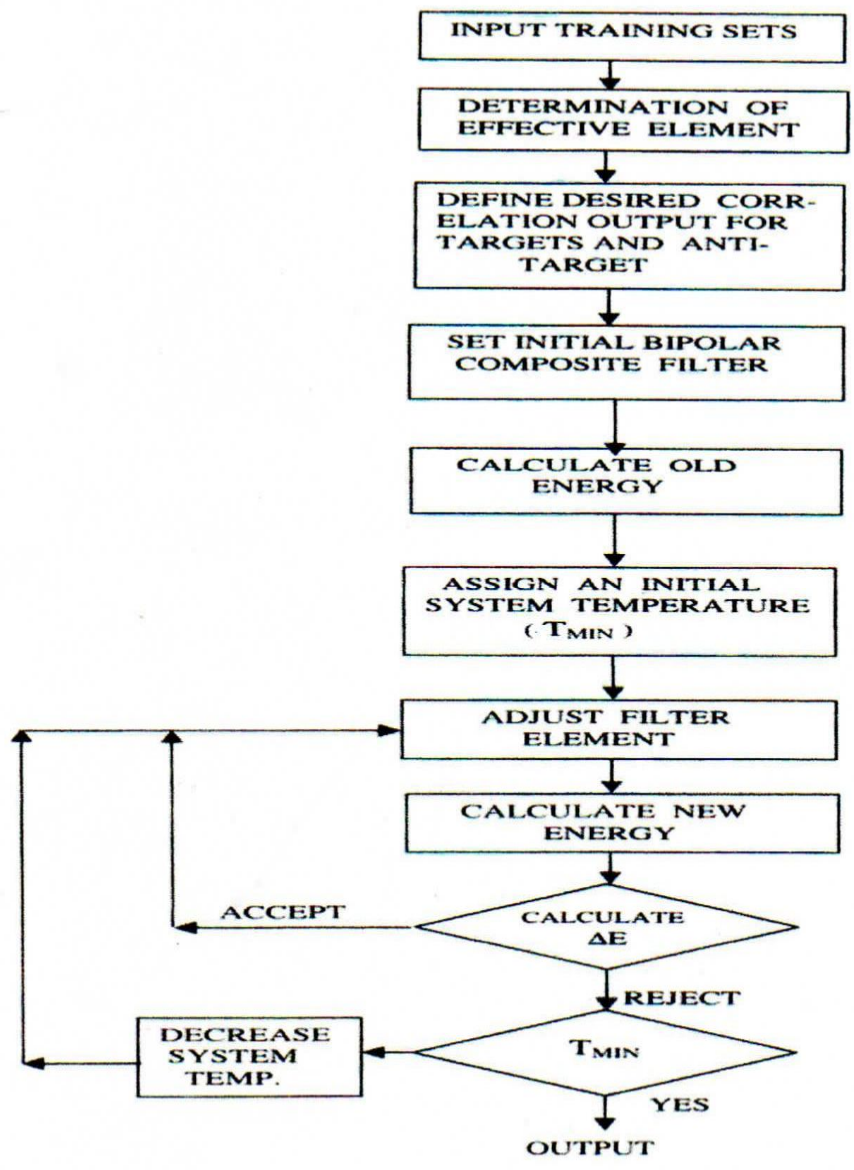

Fig. 2: Flow chart synthesizing the BCF with the simulated annealing algorithm.

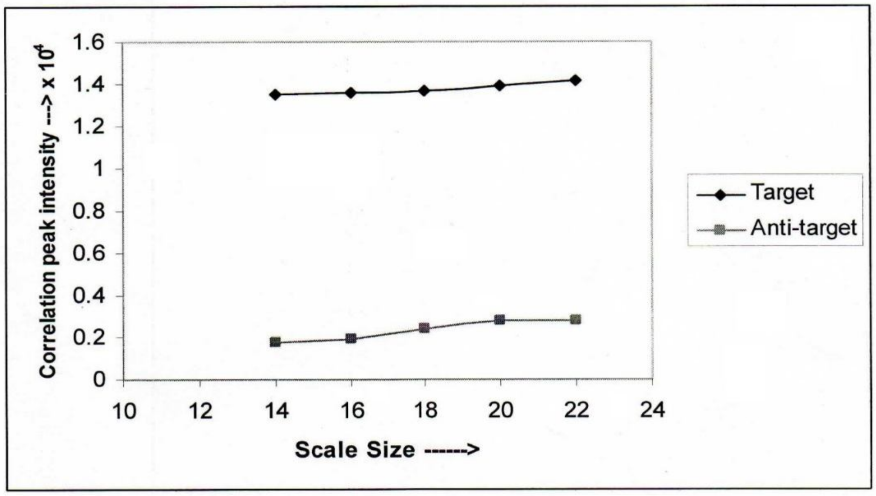

Fig. 3: Computed correlation peak intensities as function of scale size for target image (letter A) and Anti-target image (letter B).

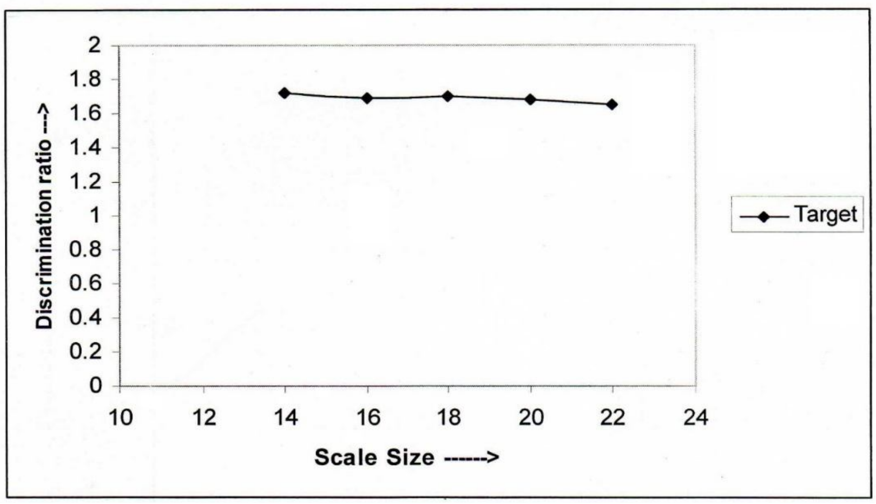

Fig. 4: Computed discrimination ratio as a function of scale size for target image (letter A).

3. SIMULATION RESULTS AND DISCUSSION

Target and anti-target images of size 32x32 are created in PAINTBRUSH utility of window. These images are converted into binary images of size 32x32 pixels in PICTUREMAN utility of window. The above binary images are read into a MATLAB program in a matrix of size 32x32. Simulation is performed with these binary images using the MATLAB program.

Figure 1(a) & 1(b) show sets of target and anti-target images, each image differs by scale size 2, which are read into MATLAB program. Figure 2 shows the flow chart of simulated annealing algorithm for synthesizing the BCF. The correlation peak intensities for target and anti-target training sets Vs scale size have been depicted in the Figure 3. The results show very high intensity peaks for target and low intensity peaks for anti-target images are obtained. The discrimination ratio for target images of different scale size has been plotted in Figure 4, which shows bipolar composite filter has good discrimination capability for target and anti-target images of different scale size.

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