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DIFFERENT VIEWING POSITION OF CHARACTER RECOGNITION SYSTEM IN NEURAL NETWORK MODEL USING ADAPTIVE RESONANCE THEORY1 ALGORITHMIC APPROACH

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ABSTRACT

Nowadays character recognition system has been gain a lot of more attention in the field of pattern recognition due to its various applications in various fields. The off-line character recognition is a process which is used to recognition the pattern. In this research paper based on the Recognition of English alphabet letters in a given handwritten text with various strokes that could be help of using Matlab, Neural Network toolbox. Neural network has demonstrated its capability for solving complex character recognition problems. The work of this paper it is developed off-line strategies for the isolated handwritten English character (26 uppercase letters & 26 lowercase letters). Preprocessing of the Character is used Binarization, Thresholding and segmentation method. The proposed method is based on the use of Multi layer feed forward network Adaptive Resonance Theory method to classify the characters. The ANN is trained by using the Adaptive Resonance Theory1 Algorithmic Approach. In the proposed system, English numerical letter is represented by binary numbers that are used as input then they are feed to an ANN. Neural network followed by the Adaptive Resonance Theory1 Algorithm which compromises Training.

Key words: Adaptive Resonance Theory, Character recognition, Image recognition, Neural Network, Training and Testing Data set, Tool Box, Mat Lab.

I. INTRODUCTION

In this machine learning world, English Hand Written Character Recognition has been a challenging and interesting research area in the field of Artificial Intelligence [1]. Character recognition is an art of detecting segmenting and identifying characters from image. More precisely Character recognition is a process of detecting and recognizing characters from input image and converts it into ASCII or other equivalent machine editable form [1], [2], [3]. It contributes immensely to the advancement of automation process and improving the interface between man and machine in many applications [4]. Character recognition is one of the most interesting and fascinating areas of pattern recognition and artificial intelligence [5], [6].Character recognition is getting more and more attention since last decade due to its wide range of application.

Character recognition is the process to classify the input character according to the predefined character class. With the increasing interest of computer applications, modern society needs that the computer should read the text. The text may be in the form of scanned handwritten document or typed text in various fonts or a combination of both. The character recognition system helps in making the communication between a human and a computer easy. Classical methods in recognition are not perfect for the recognition of visual characters due to the following reasons [12]:

1. The same characters differ in sizes, shapes and styles from person to person and even from time to time with the same person. The source of confusion is the high level of abstraction: there are thousands styles of type in common use and a character recognition program must recognize most of these.
2. Like any image, visual characters are subject to spoilage due to noise. Noise consists of random changes to a pattern, particularly near the edges. A character with much noise may be interpreted as a completely different character by a computer program.
3. There are no hard-and-fast rules that define the appearance of a visual character. Hence rules need to be heuristically deduced from the samples. Character recognition system is useful in license plate recognition system, smart card processing system, automatic data entry, bank cheque /DD processing, money counting machine, postal automation, address and zip code recognition, writer identification etc. There exist several different techniques for recognizing characters. One distinguishes characters by the number of loops in a character and the other by direction of their concavities. These methods can be used one after the other to increase accuracy and speed for recognition.

Generally, character recognition can be broadly characterized into two types (i) Offline and (ii) Online. In offline method, the pattern is captured as an image and taken for testing purpose. But in case of online approach, each point of the pattern is a function of pressure, time, slant, strokes and other physical parameters. Both the methods are best based on their application in the field of machine learning. Yielding best accuracy with minimal cost of time is a crucial precondition for pattern recognition system. Therefore, hand written character recognition is continuously being a broad area of research.

In this work, an approach for offline English character recognition has been proposed using Artificial Neural Network (ANN). ANN basically resembles with the characteristics of a Knowledge bases of the ANN are the inter-neural weights.

II. LITERATURE REVIEW:

Adaptive Resonance Theory1is an unsupervised learning process studying distribution of a set of patterns without any class information. The basic idea of this technique is understood from how human brain stores images/patterns that have been recognized through eyes, and then human brain is able to reveal the images/ patterns back. Therefore, the application of this model is widely used in object recognition or visual image.

Handwriting recognition is an ability of a computer to receive input in the form of understandable handwriting. Principally, handwriting recognition requires optical character recognition. The handwriting recognition system completely handles formatting, performs segmentation, and finds the most appropriate word. Handwriting recognition is used for editing, annotation, other applications that are difficult to interact directly, and applications using direct manipulation and pointing. Tablet is a powerful tool as the input of handwriting because tablet can receive both text and graphics. There are many electronic devices that can be used as a tool in Handwriting recognition such as a mobile device/smart phone [8,9,10]. Research on the utilization of input devices such as electronic pen was also conducted by Sreeraj [11].

Handwriting consists of a time sequence of stroke (movement), i.e. movement of writing started from pen down to pen up, character writing is usually formed in a sequence, one character is

complete before starting the next one, a character usually starts from left to right. In some cases there are exceptions. For example in English script, crosses (for t and x) and point (for i and j) tend to be a delay in writing [7].

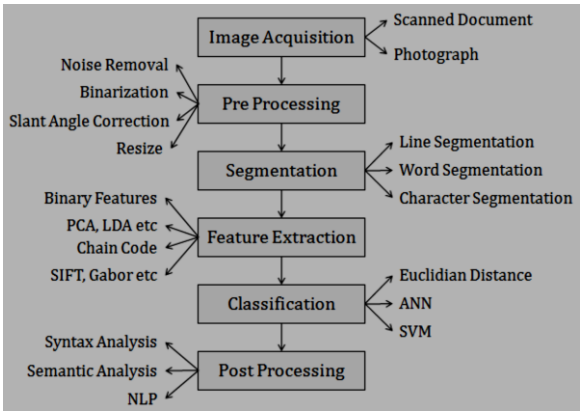

Fig 1: Block Diagram of Character Recognition System

Image acquisition: Images for HCR system might be acquired by scanning handwritten document or by capturing photograph of document or by directly writing in computer using stylus. This is also known as digitization process.

Preprocessing: Preprocessing involves series of operations performed to enhance to make it suitable for segmentation [4]. Preprocessing step involves noise removal generated during document generation.

Proper filter like mean filter, min-max filter, Gaussian filter etc may be applied to remove noise from document. Binarization process converts gray scale or colored image to black and white image. Binary morphological operations like opening, closing, thinning, whole filling etc may be applied to enhance visibility and structural information of character.

If document is scanned then it may not be perfectly horizontally aligned, so we need to align it by performing slant angle correction. Input document may be resized if it is too large in size to reduce dimensions to improve speed of processing. However reducing dimension below certain level may remove some useful features too.

Segmentation: Generally document is processed in hierarchical way. At first level lines are segmented using row histogram. From each row, words are extracted using column histogram and finally characters are extracted from words. Accuracy of final result is highly depends on accuracy of segmentation.

Feature Extraction: Feature extraction is the heart of any pattern recognition application. Feature extraction techniques like Principle Component Analysis (PCA), Linear Discriminated Analysis (LDA), Independent Component Analysis (ICA), Chain Code (CC), Scale Invariant Feature Extraction (SIFT), zoning, Gradient based features, Histogram might be applied to extract the features of individual characters. These features are used to train the system.

Classification: When input image is presented to HCR system, its features are extracted and given as an input to the trained classifier like artificial neural network or support vector machine. Classifiers compare the input feature with stored pattern and find out the best matching class for input.

Post processing: This step is not compulsory; sometimes it helps to improve the accuracy of recognition. Syntax analysis, semantic analysis kind of higher level concepts might be applied to check the context of recognized character.

III. METHODOLOGY

There are many neural network algorithms for the pattern recognition. The Various algorithms differ in their learning mechanism and Learning can be either supervised or unsupervised. In supervised learning, the training set contains both inputs and required responses. After training the network, and get the result of response that is equal to target response. Unsupervised classification learning is based on clustering of input data. There is no prior information about input's membership in a particular class. The Image as the patterns and a history of training is used to assist the network in defining classes. This unsupervised classification is called clustering.

The Image as a pattern of neurons and initial weights are specified based upon the training method of the network. The pattern sets is applied to the network during the training [7]. The pattern is to be recognized in the form of vector, whose

elements is obtained from a pattern grid. The elements are either binary values 0 and 1 or bipolar values -1 and 1. In some of the algorithms, weights are calculated from the pattern presented to the network and in some algorithms weights are initialized. The network acquires the knowledge from the environment. The network stores the patterns presented during the training in another way it extracts the features of pattern. Neural networks have demonstrated its capability for solving complex pattern recognition problems [9]. Commonly solved problems of pattern have limited scope. Single neural network architecture can recognize only few patterns. Various neural network algorithms with their implementation details for solving pattern recognition problems. The relative performance evaluation of these algorithms has been carried out.

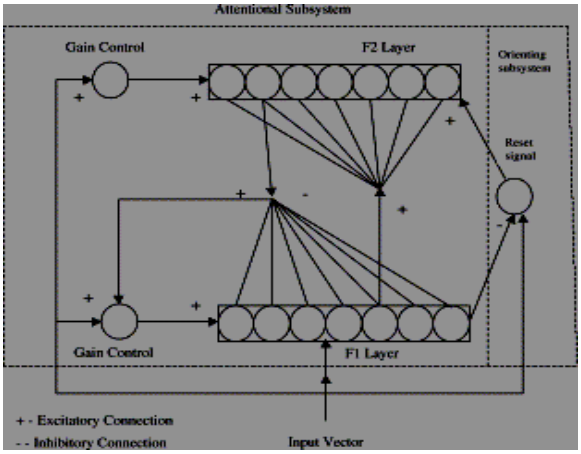

Fig 2: Adaptive Resonance Theory1 Architecture

The (Figure 1) ART1 Architecture simplified model consists of two layers of binary neurons (with values 1 and 0), called F1 and F2.

ATR1 model consists of an "Attentional" and an "Orienting" subsystem. The Attentional sub-system consists of two competitive networks, as Comparison layer F1 and Recognition layer F2, fully connected with top-down and bottom-up weights;two control gains, as Gain1 and Gain2.The pattern vector is input to comparison layer F1[12]. The Orienting sub-system consist of Reset layer for controlling the attentional sub-system overall dynamics based on vigilance parameter. Vigilance parameter determines the degree of mismatch to be tolerated between the input pattern vectors and the weights connecting **F1** and **F2**.The nodes at **F2** represent the clusters formed. Once the network stabilizes, the top-down weights corresponding to each node in **F2** represent the prototype vector for that node.

Each neuron in F1layer is also called Comparison layer or input layer (short term memory (**STM**)) is connected to all neurons in F2 is also called Recognition layer or output layer (short term memory (**STM**)) via the continuous-valued forward wij , and vice versa via the binary-valued backward vji. Bottom-up connections from F1 to F2 layer; traces of long term memory (LTM). Top-down connections from F2 to F1 layer; traces of long term memory (LTM). **Inhibitory connection** (-ve weights) from F2 layer to gain control. **Excitatory connection** (+ve weights) from gain control to F1 and F2. **Inhibitory connection** (-ve weights) from F1 layer to Reset node. **Excitatory connection** (+ve weights) from Reset node to F2 layer. The other modules are gain 1 and gain 2 (G1 and G2), and a reset module.

Each neuron in the comparison layer receives three inputs: a component of the input pattern, a component of the feedback pattern, and a gain G1. A neuron outputs a 1 if and only if at least three of these inputs are high: the 'two-thirds rule. The neurons in the recognition layer each compute the inner product of their incoming (continuous-valued) weights and the pattern sent over these connections. The winning neuron then inhibits all the other neurons via lateral inhibition. Gain 2 is the logical 'or' of all the elements in the input pattern x. Gain 1 equals gain 2, except when the feedback pattern from F2 contains any 1; then it is forced to zero. Finally, the reset signal is sent to the active neuron in F2 if the input vector x and the output of F1 by more than some vigilance level [12].

IV. TRAINING AND TESTING

The ART1is a computationally efficient method for changing the weights to learn training set of input- output with different activation function and learning rate. The network has some of the neurons in first layer and few neurons in the second layer. Usually, the number of nodes in each layer determines the structure of network. The

number of nodes in the input layer is made equal to features extracted to represent the character and these highly influence the performance and complexity of network.

The number of nodes in output layer is made equal to the number of classes in the database. With this configuration the network is capable of storing seven alphabets. The alphabets have been represented as a pattern grid of size 9×9. From the pattern grid each alphabet is obtained in the form of a vector with Binary Values entries 0and 1. All the alphabets in the form of different sets and its associated output is stored. Weight matrix is obtained by taking inner product of different sets. The network has been Trained and tested for both upper case and lowercase letters. The network gives the correct associated output when these characters are given at the time of testing. The following table shows the training data where used to train the neurons for recognizing the uppercase letters.

Table 1: Upper case Characters Training dataset

Characters	Input Data
A	[0 0 1 1 0 0 0; 0 0 0 1 0 0 0;0 0 0 1 0 0 0 ; 0 0 1 0 1 0 0; 0 0 1 0 1 0 0 ; 0 1 1 1 1 1 0; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0; 1 1 1 0 1 1 1];
B	[1 1 1 1 1 1 0;0 1 0 0 0 0 1;0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 1 1 1 1 0; 0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 1 0];
C	[0 0 1 1 1 1 1 ; 0 1 0 0 0 0 1; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0; 0 1 0 0 0 0 1; 0 0 1 1 1 1 0];
D	[1 1 1 1 1 0 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1 0 0 0 0 1;0 1 0 0 0 0 1; 0 1 0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 0 0];
E	[1 1 1 1 1 1 1; 0 1 0 0 0 0 1; 0 1 0 0 0 0 0 ; 0 1 0 1 0 0 0 ;0 1 1 1 0 0 0 ;0 1 0 1 0 0 0 ;0 1 0 0 0 0 0 ; 0 1 0 0 0 0 1; 1 1 1 1 1 1 1];
F	[1 1 1 1 1 1 1;1 0 0 0 0 0 1;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0 ;1 1 1 1 1 0 0 ;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0;1 0 0 0 0 0 0];
G	[1 1 1 1 1 1 1; 1 0 0 0 0 0 1; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 1 1 1 1 ; 1 0 0 1 0 0 1 ; 1 0 0 1 0 0 1 ; 1 0 0 1 0 0 1; 1 1 1 1 0 0 1];
H	[1 1 0 0 0 1 1; 1 0 0 0 0 0 1; 1 0 0 0 0 0 1 ; 1 0 0 0 0 0 1 ;1 1 1 1 1 1 1 ;1 0 0 0 0 0 1 ;1 0 0 0 0 0 1 ; 1 0 0 0 0 0 1; 1 1 0 0 0 1 1];
I	[1 1 1 1 1 1 1; 1 0 0 1 0 0 1; 0 0 0 1 0 0 0 ; 0 0 0 1 0 0 0 ;0 0 0 1 0 0 0 ;0 0 0 1 0 0 0;0 0 0 1 0 0 0 ; 1 0 0 1 0 0 1; 1 1 1 1 1 1 1];
J	[0 0 0 1 1 1 1;0 0 0 0 0 1 0;0 0 0 0 0 1 0; 0 0 0 0 0 1 0; 0 0 0 0 0 1 0; 0 0 0 0 0 1 0; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0; 0 0 1 1 1 0 0];
K	[1 1 1 0 0 1 1 ; 0 1 0 0 1 0 0 ;0 1 0 1 0 0 0 ;0 1 1 0 0 0 0 ;0 1 1 0 0 0 0 ;0 1 0 1 0 0 0 ; 0 1 0 0 1 0 0 ;0 1 0 0 0 1 0;1 1 1 0 0 1 1];
L	[1 1 0 0 0 0 0; 1 0 0 0 0 0 0; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ;1 0 0 0 0 0 0 ;1 0 0 0 0 0 0;1 0 0 0 0 0 0 ; 1 0 0 0 0 0 1; 1 1 1 1 1 1 1];
M	[1 1 0 0 0 0 1;1 1 0 0 0 0 1;1 0 1 0 0 1 1 ;1 0 0 1 1 0 1;1 0 0 1 1 0 1 ;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 0 0 0 0 0 1; 1 0 0 0 0 0 1];
N	[1 0 0 0 0 0 1;1 1 0 0 0 0 1;1 0 1 0 0 0 1;1 0 0 1 0 0 1;1 0 0 1 0 0 1;1 0 0 1 0 0 1;1 0 0 1 0 0 1;1 0 0 0 1 0 1;1 0 0 0 0 1 1];
O	[0 0 1 1 1 0 0;0 1 0 0 0 1 0;1 0 0 0 0 0 1 ;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 0 0 0 0 0 1 ;1 0 0 0 0 0 1;0 1 0 0 0 1 0;0 0 1 1 1 0 0];
P	[1 0 1 1 1 1 0;0 1 0 0 0 1 0; 0 1 0 0 0 1 0 ;0 1 0 0 0 1 0; 0 1 1 1 1 1 0;0 1 0 0 0 0 0 ;0 1 0 0 0 0 0; 0 1 0 0 0 0 0;1 1 1 0 0 0 0];
Q	[0 1 1 1 1 1 0;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 0 0 0 0 0 1;1 0 1 0 0 0 1;1 0 0 1 0 0 1 ;0 1 1 1 1 1 0;0 0 0 0 1 0 0;0 0 0 0 0 1 0];
R	[1 1 1 1 1 1 0;0 1 0 0 0 1 0;0 1 0 0 1 0 0 ;0 1 0 1 0 0 0;0 1 1 1 0 0 0;0 1 0 0 1 0 0 ;0 1 0 0 0 1 0;0 1 0 0 0 1 0;1 1 0 0 0 1 1];
S	[0 0 1 1 1 1 0;0 1 0 0 0 1 0;0 1 0 0 0 0 0 ;0 1 0 0 0 0 0;0 0 1 0 0 0 0;0 0 0 1 1 0 0 ;0 0 0 0 0 1 0;1 0 0 0 1 0 0;0 1 1 1 1 0 0];
T	[1 1 1 1 1 1 1;1 0 0 1 0 0 1; 0 0 0 1 0 0 0 ;0 0 0 1 0 0 0;0 0 0 1 0 0 0;0 0 0 1

	0 0 0 ;0 0 0 1 0 0 0;0 0 0 1 0 0 0;0 0 1 1 1 0 0];
U	[1 1 0 0 0 1 1;0 1 0 0 0 1 0; 0 1 0 0 0 1 0;0 1 0 0 0 1 0;0 1 0 0 0 1 0;0 1 0 0 0 1 0; 0 1 0 0 0 1 0; 0 0 1 1 1 0 0];
V	[1 1 0 0 0 1 1;0 1 0 0 0 1 0;0 1 0 0 0 1 0 ;0 1 0 0 0 1 0;0 1 0 0 0 1 0;0 1 0 0 0 1 0 ;0 1 0 0 0 1 0;0 0 1 0 1 0 0;0 0 0 1 0 0 0];
W	[1 1 0 0 0 1 1;1 0 0 0 0 0 1;1 0 0 1 0 0 1 ;1 0 0 1 0 0 1;1 0 0 1 0 0 1 ;1 0 1 0 1 0 1;1 1 0 0 0 1 1;1 0 0 0 0 0 1];
X	[1 1 0 0 0 1 1;0 1 0 0 0 1 0;0 1 0 0 0 1 0 ;0 0 1 0 1 0 0;0 0 0 1 0 0 0;0 0 1 0 1 0 0 ;0 1 0 0 0 1 0;0 1 0 0 0 1 0;1 1 0 0 0 1 1];
Z	[1 1 1 1 1 1 1;1 0 0 0 0 0 1;0 0 0 0 0 0 1;0 0 0 0 0 1 0;0 0 0 0 1 0 0;0 0 0 1 0 0 0 ;0 0 1 0 0 0 0;0 1 0 0 0 0 1;1 1 1 1 1 1 1];

The following table shows the training data where used to train the neurons for recognizing the lower case letters.

Table 2: Lower case Characters Training dataset

Characters	Input Data
a	[0 0 1 1 1 0 0; 0 1 0 0 1 0 0;1 0 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 0 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 1 1 1 1 0 1; 0 0 0 0 1 1 1; 0 0 0 0 0 0 0];
b	[1 1 0 0 0 0 0;0 1 0 0 0 0 0;0 1 0 0 0 0 0; 0 1 0 0 0 0 0; 0 1 1 1 1 1 0; 0 1 0 0 0 0 1;0 1 0 0 0 0 1; 0 1 0 0 0 1 0; 1 1 1 1 1 1 0];
c	[0 0 0 0 0 0 0 ; 0 0 0 0 0 0 0; 0 1 1 1 1 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0 ; 1 0 0 0 0 0 0; 0 1 1 1 1 0 0; 0 0 0 0 0 0 0];
d	[0 0 0 0 0 0 0 ; 0 0 0 0 0 0 0; 0 0 0 0 0 0 1 0 ; 0 0 0 0 0 1 0 ; 0 0 0 0 0 1 0 ; 0 1 1 1 1 1 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0; 0 0 1 1 1 1 1];
e	[0 0 0 0 0 0 0;0 0 1 1 1 0 0;0 1 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 0 0 0 1 0 0 ; 1 1 1 1 0 1 0; 0 1 0 0 1 0 0; 0 0 1 1 0 0 0; 0 0 0 0 0 0 0];
f	[0 0 0 0 1 1 0;0 0 0 0 1 0 1;0 0 0 0 1 0 1 ; 0 0 0 0 1 0 0; 0 0 0 0 1 0 0 ; 0 0 0 1 1 1 0; 0 0 0 0 1 0 0; 1 0 0 0
	1 0 0; 0 1 1 1 1 0 0];
g	[0 0 1 1 1 1 0;0 1 0 0 0 1 0;0 1 0 0 0 1 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0 ; 0 0 1 1 1 1 0; 0 0 0 0 0 1 0; 1 0 0 0 0 1 0; 0 1 1 1 1 1 0];
h	[0 0 0 0 0 0 0; 0 1 0 0 0 0 0;0 1 0 0 0 0 0 ; 0 1 0 0 0 0 0; 0 1 1 1 1 0 0 ; 1 1 0 0 1 0 0; 0 1 0 0 1 0 0; 0 1 0 0 1 0 1; 0 0 0 0 0 1 0];
i	[0 0 0 0 0 0 0;0 0 0 1 0 0 0;0 0 0 0 0 0 0 ; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0 ; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 0 0 0 0];
j	[0 0 0 0 1 0 0;0 0 0 0 0 0 0;0 0 0 0 1 0 0 ; 0 0 0 0 1 0 0; 0 0 0 0 1 0 0 ; 0 1 0 0 1 0 0; 0 1 0 0 1 0 0; 0 0 1 1 1 0 0; 0 0 0 0 0 0 0];
k	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;1 0 0 1 0 0 0 ; 1 0 1 0 0 0 0; 1 1 0 0 0 0 0 ; 1 0 1 0 0 0 0; 1 0 0 1 0 0 0; 0 0 0 0 0 0 0; 0 0 0 0 0 0 0];
l	[0 0 0 1 0 0 0;0 0 0 1 1 0 0;0 0 0 1 0 1 0 ; 0 0 0 1 0 1 0; 0 0 0 1 1 0 0 ; 0 0 0 1 0 0 0; 0 0 1 1 0 0 1; 0 1 0 1 0 1 0; 1 0 0 1 1 0 0];
m	[0 0 0 0 0 0 0;1 0 1 0 1 0 0;0 1 0 1 0 1 0 ; 1 0 0 1 0 1 0; 1 0 0 1 0 1 0 ; 1 0 0 1 0 1 0; 1 0 0 1 0 1 0; 1 0 0 1 0 1 0; 0 0 0 0 0 0 0];
n	[0 0 0 0 0 0 0;0 1 1 1 1 0 0;1 0 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 0 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 0 0 0 1 0 0; 0 0 0 0 0 0 0; 0 0 0 0 0 0 0];
o	[0 0 0 0 0 0 0; 0 0 1 1 1 0 0;0 1 0 0 0 1 0 ; 0 1 0 0 0 1 0; 0 1 0 0 0 1 0 ; 0 1 0 0 0 1 0; 0 0 1 1 1 0 0; 0 0 0 0 0 0 0; 0 0 0 0 0 0 0];
p	[0 0 0 0 0 0 0; 1 0 1 1 1 0 0;0 1 0 0 0 1 0 ; 0 1 0 0 0 1 0; 0 1 1 1 1 1 0 ; 0 1 0 0 0 0 0; 0 1 0 0 0 0 0; 0 1 0 0 0 0 0; 1 0 0 0 0 0 0];
q	[0 0 0 0 0 0 0;0 1 1 1 0 0 0;1 0 0 0 1 0 0 ; 1 0 0 0 1 0 0; 1 0 0 0 1 0 0 ; 0 1 1 1 1 0 0; 0 0 0 0 1 0 1; 0 0 0 0 1 0 1; 0 0 0 0 0 1 0];
r	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;0 1 0 0 0 1 0 ; 1 0 1 0 1 0 1; 0 0 0 1 0 0 0 ; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 0 0 0 0];
s	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;0 0 1 1 1 0 0 ; 0 1 0 0 0 0 0; 0 1 0 0 0 0 0 ;

	0 0 1 1 0 0 0; 0 0 0 0 1 0 0; 0 1 1 1 0 0 0; 0 0 0 0 0 0 0];
t	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;0 0 0 1 0 0 0 ; 0 0 0 1 0 0 0; 0 0 1 1 1 0 0 ; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0; 0 0 0 1 0 1 0; 0 0 0 1 1 0 0];
u	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;1 0 0 0 0 0 0 ; 0 1 0 0 1 0 0; 0 1 0 0 1 0 0 ; 0 1 0 0 1 0 0; 0 1 0 0 1 0 0; 0 0 1 1 1 1 1; 0 0 0 0 0 0 0];
v	[0 0 0 0 0 0 0; 0 0 0 0 0 0 0;0 0 0 0 0 0 0 ; 0 0 0 0 0 0 0; 1 0 0 0 0 0 1 ; 0 1 0 0 0 1 0; 0 0 1 0 1 0 0; 0 0 0 1 0 0 0; 0 0 0 0 0 0 0];
w	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;0 0 0 0 0 0 0 ; 0 0 0 0 0 0 0; 1 0 0 0 0 0 1 ; 1 0 0 1 0 0 1; 1 0 1 0 1 0 1; 0 1 0 0 0 1 0; 0 0 0 0 0 0 0];
x	[1 0 0 0 0 0 1;0 1 0 0 0 1 0;0 0 1 0 1 0 0 ; 0 0 0 1 0 0 0; 0 0 0 1 0 0 0 ; 0 0 0 1 0 0 0; 0 0 1 0 1 0 0; 0 1 0 0 0 1 0; 1 0 0 0 0 0 1];
y	[0 0 0 0 0 0 0; 0 0 0 0 0 0 0;0 1 0 0 1 0 0 ; 0 1 0 0 1 0 0; 0 1 0 0 1 0 0 ; 0 1 1 1 1 0 0; 0 0 0 0 1 0 0; 0 1 0 0 1 0 0; 0 0 1 1 0 0 0];
z	[0 0 0 0 0 0 0;0 0 0 0 0 0 0;0 1 1 1 0 0 0 ;0 0 0 0 1 0 0;0 0 0 1 0 0 0;0 0 1 0 0 0 0 ;0 1 1 1 1 1 0 0;0 0 0 0 0 0 0 0;0 0 0 0 0 0 0 0];

V. RESULT

The data used in this research works are lower case characters a-z and upper case characters A-Z. The size of handwritten character data is 9x9 pixels. The recognition process of some handwritten characters as follow:

Characters*:* The off line handwritten character recognition process is Binarization characters. The Binarization character process can see in Fig.3 and Fig 4.

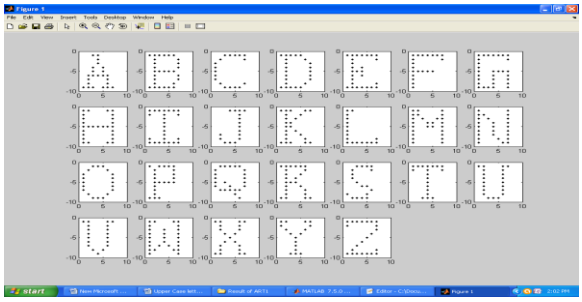

Fig 3: Character Recognition for Upper Case

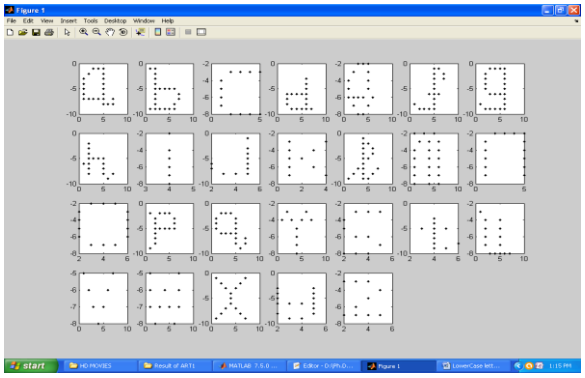

Fig 4: Character Recognition for Lowercase Case

VI. CONCLUSION

This research work proposed an Adaptive resonance theory algorithmic approach for recognizing hand written English alphabets. The algorithm is based on principle of Artificial Neural Network (ANN). However, the algorithm was tested with 26 capital letters set and 26 small letters set. The result and discussion section showed that the developed algorithm works well with maximum recognition rate and minimum False Rejection Rate. As future work, it will be interesting to test the developed algorithm with more Strokes of English alphabet samples.

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