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## The Notation Scanner Systems using Resilient Backpropagation Method

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### Abstract

This research proposes a notation scanner system for numerical notation. This research was supported by using resilient backpropagation algorithm and uses the music application to get a melody of musical instruments. Objects used are designed to be focused on the numerical notation symbols. To be implemented, the input image from camera will be pre-processing, image segmentation, number and symbol recognition, output sound, and to read numerical notation symbols before entering resilient backpropagation algorithm. The image will be 21x21 pixels. By using colour filtering can reduce errors in handwriting recognition. Success rate by using 15 new sample data with 100 sample data training, the test to get a successful outcome as much as 87.9% and 12.1% error while success rate by using 15 new sample data with 50 sample data training, the test to get a successful outcome as much as 74.4% and 25.6% error.

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### 1. Introduction

The development of information technology in specific area of computational intelligence has been developed very rapidly such as computer vision and robotics. As in today's society has been living in the globalization era, an era in which the views, products, ideas, and other cultural aspects of each part of the world are able to integrate with each other increasingly influenced by modern technology. Vision-based computer technology has become a part of everyone's life. The latest technology in the field of computer vision has profound implications for companies and individuals, one of them in the music industry.

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Only 8 students or 20% are able to read and write numerical notation of the number of students as many as 40 people. Students is still difficulty in reading numerical notation especially at the level of understanding of the form and note values, the sound tone used in the numerical notation like the sound of the tone of do-re-mi-fa-sol-la-si, how to read the knock-bar notes  $1/4$ ,  $1/2$ ,  $1/8$ , and others. Based on these issues, students still do not understand and do not fully understand what the teacher to convey to learning material the art of music.

Many research focusing on reading numbers or symbol based on computer vision, such as reading the Indian numbers through pre-processing operations such as segmentation, binarization, normalization, and location<sup>2</sup>. In previous research<sup>3</sup>, English alphabet as a binary value that used as input for simple feature extraction system, whose output is fed to the neural system. Hence it developed an application that can recognize the numerical notation. Objectives of the development of this application is to develop an application that can recognize the shape of the numerical notation using neural network technique with resilient backpropagation algorithm and can secrete melody of music, the development of these applications can help people who want to enjoy a musical of sheet music numerical notation and can learn music by using sheet music numerical notation.

The benefits to be gained by using a neural network technique with resilient backpropagation algorithm in the form of an application can recognize and use music applications that can secrete musical melody, and help users to listen music without having to master the melody sheet music numerical notation, thereby increasing the public's attention will taste curious about the music, and the user can explore the hobby of listening to musical instruments.

## 2. Proposed Method

We propose our system based on the flow diagram shown in figure 1:

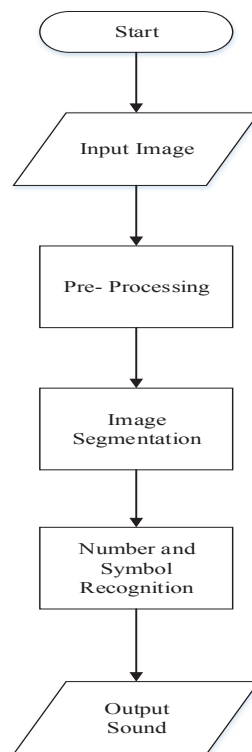


Figure 1. Application flow diagram

At the initial stage, user will input an image in the white paper (HVS) which contains note number along with its symbols. This image input process, done by the user confronts the white paper (HVS) on the next camera. At the pre-processing stage, after the user to input image, display or image by capture the camera will be processed through some kind of process in image processing, will experience the stages of grayscale, brightness, contrast, threshold and canny image. Image segmentation is the stage where the text

object is in the white paper will be divided into pieces of pixels that have a size equal to the size of the object and then the image will be in the crop after resize. The image will be the resize to 21x21 pixels. After going through the image segmentation, this will be the next stage is pattern recognition. The pattern of results obtained from the training has been done by the programmer, so that the image can be recognized as numbers or symbols. This stage is the last stage in the application is to output a sound based on the recognised notation.

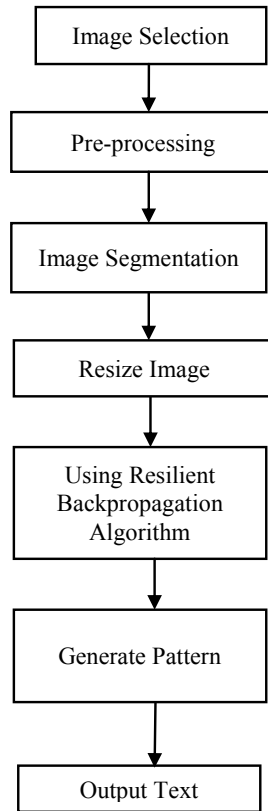


Fig. 2. Proses Symbol Notation Recognition

Here is an explanation of proses symbol notation recognition used in this application:

1. Pre-processing  
Pre-processing aims to create images that will be processed into blur and then into a grey, so that it can be processed into a binary image and slightly reduce noise in the image so that it can assist in the process of segmentation. Before that of all, it can be processed to reduce or increase brightness and contrast to get maximum reduce of noise from images.
2. Image Segmentation  
This process aims to separate the numbers and symbols on one line which is useful for cutting the characters on one line using convex hull method.
3. Resize Image (21x21 pixels)  
This process aims to make the image the same size as with the image training so can be inserted into the neural network.
4. Using Resilient Backpropagation Algorithm  
This process aims to data recognition into the neural network in order to obtain the output based on the weight of the data obtained from the training.
5. Generate Pattern  
This process aims to make pattern design from output the neural network.

In this experiment we used a webcam camera, where the camera captured a RGB image. However, the image has some glitches that can reduce the quality of the image. One was from a decrease image quality derived from

the optical lens system digital camera. When the camera is out of focus, then the captured image will be blurry<sup>1</sup>. We suggest to focus, when capture an image.

To get every single object in image, we used convex hull method. Convex hull is used to understand the contours of an object. Convex hull as a guide in conducting object detection<sup>4</sup>. Backpropagation is used to train the network in order to identify patterns used during training as well as the network’s ability to provide a response to the input pattern similar to the pattern used during the training<sup>5</sup>.

The main difference from other techniques is that each step independent of the absolute value of the partial derivation. 1 (one) iteration of the original algorithm RPROP can be separated into two (2) sections. The first part, adjust the step-sizes, essentially the same for all of the algorithms used. For each weight  $w_{ij}$  an individual step-size  $\Delta_{ij}$  adjust using the following rule<sup>6</sup>:

$$\Delta_{ij}^{(t)} := \begin{cases} \eta^+ \cdot \Delta_{ij}^{(t-1)}, & \text{If } \frac{\partial E^{(t-1)}}{\partial w_{ij}} * \frac{\partial E^{(t)}}{\partial w_{ij}} > 0 \\ \eta^- \cdot \Delta_{ij}^{(t-1)}, & \text{If } \frac{\partial E^{(t-1)}}{\partial w_{ij}} * \frac{\partial E^{(t)}}{\partial w_{ij}} < 0 \\ \Delta_{ij}^{(t-1)}, & \text{Else,} \end{cases} \quad (1)$$

Where  $0 < \eta^- < 1 < \eta^+$ . If the partial derivative  $\partial E/\partial w_{ij}$  has the same sign for sequential step, the step-size will increase, which if it changes sign, then the step-size will decrease. Step-size bound with parameter  $\Delta_{min}$  and  $\Delta_{max}$ . The second part of the algorithm, the weight update. Size is determined by the weight change exclusively specific weight.

$$\Delta w_{ij}^{(t)} := \begin{cases} -\Delta_{ij} (t), & \text{If } \frac{\partial E(t)}{\partial w_{ij}} > 0 \\ +\Delta_{ij} (t), & \text{If } \frac{\partial E(t)}{\partial w_{ij}} < 0 \\ 0, & \text{Else,} \end{cases} \quad (2)$$

RPROP algorithms require the setting of following parameters: (i) increase factor for  $\eta^+ = 1.2$ ; (ii) reducing factor for  $\eta^- = 0.5$ ; (iii) Inisial update-value for  $\Delta_0 = 0.1$ ; (iv) Maximum weight measures, which are used in order to prevented or weight becomes too large, is  $\Delta_{max} = 50$ .

After adjusting the step-sizes, determine the weight renewal  $\Delta w_{ij}$ . There are two cases to distinguish. If the sign of the partial derivative does not change, a regular weight update is executed:

$$\text{if } \frac{\partial E^{(t-1)}}{\partial w_{ij}} \cdot \frac{\partial E^{(t)}}{\partial w_{ij}} \geq 0 \quad \text{then} \\ \Delta w_{ij}^{(t)} = -\text{sign} \left( \frac{\partial E^{(t)}}{\partial w_{ij}} \right) \cdot \Delta_{ij}^{(t)}, \quad (3)$$

Where the operator marks +1 if the argument is positive, -1 if the argument is negative, and 0 otherwise. In case of changing the sign of the partial derivation, weight change before returning:

$$\text{if } \frac{\partial E^{(t-1)}}{\partial w_{ij}} \cdot \frac{\partial E^{(t)}}{\partial w_{ij}} < 0 \quad \text{then} \\ \Delta w_{ij}^{(t)} = -\Delta w_{ij}^{(t-1)} \quad \text{and} \quad \frac{\partial E^{(t)}}{\partial w_{ij}} = 0. \quad (4)$$

Set the stored derivative to 0 (zero) to avoid the change of the learning rate in the next iteration. Finally, a new weight is given by

$$w_{ij}^{(t+1)} = w_{ij}^{(t)} + \Delta w_{ij}^{(t)} \quad (5)$$

This algorithm will describe RPROP in the form of pseudo-code<sup>7</sup>. As follows:

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For each  $w_{ij}$  do
  if  $\frac{\partial E(t-1)}{\partial w_{ij}} \cdot \frac{\partial E(t)}{\partial w_{ij}} > 0$  then
     $\Delta_{ij}(t) = \min(\Delta_{ij}(t-1) \cdot \eta^+, \Delta_{max})$ 
     $\Delta w_{ij}(t) = -\text{sign}\left(\frac{\partial E(t)}{\partial w_{ij}}\right) \cdot \Delta_{ij}(t)$ 
     $w_{ij}(t+1) = w_{ij}(t) + \Delta w_{ij}(t)$ 
  elseif  $\frac{\partial E(t-1)}{\partial w_{ij}} \cdot \frac{\partial E(t)}{\partial w_{ij}} < 0$  then
     $\Delta_{ij}(t) = \max(\Delta_{ij}(t-1) \cdot \eta^-, \Delta_{min})$ 
     $w_{ij}(t+1) = w_{ij}(t) - \Delta w_{ij}(t)$ 
     $\frac{\partial E(t)}{\partial w_{ij}} = 0$ 
  elseif  $\frac{\partial E(t-1)}{\partial w_{ij}} \cdot \frac{\partial E(t)}{\partial w_{ij}} = 0$  then
     $\Delta w_{ij}(t) = -\text{sign}\left(\frac{\partial E(t)}{\partial w_{ij}}\right) \cdot \Delta_{ij}(t)$ 
     $w_{ij}(t+1) = w_{ij}(t) + \Delta w_{ij}(t)$ 

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### 3. Result and Discussion

Here are the results of research and experiments that have been on resize and crop into 21x21 pixel size, the result in the testing of new data and training data using RPROP (Resilient Back propagation) algorithm.

Table 1. Success Rate with 100 Training Data

Class	Sample	Error	Error (%)	Success	Success (%)
0	15	3	6	12	80
1	15	3	6	12	80
2	15	1	2	14	93
3	15	3	6	12	80
4	15	0	0	15	100
5	15	6	12	9	60
6	15	1	2	14	93
7	15	0	0	15	100
8	15	1	2	14	93
9	15	0	0	15	100
Success Rate					87.9

From Table 1 describes the tests performed on 100 training data. By using 15 new sample data, the test to get a successful outcome as much as 87.9% and 12.1% error.

Table 2. Success Rate with 50 Training Data

Class	Sample	Error	Error (%)	Success	Success (%)
0	15	2	4	13	86
1	15	7	14	8	53
2	15	5	10	10	66
3	15	0	0	15	100
4	15	0	0	15	100
5	15	13	26	2	13
6	15	0	0	15	100
7	15	7	14	8	53
8	15	0	0	15	100
9	15	4	8	11	73
Success Rate					74.4

From Table 2 describes the tests performed on the 50 training data. By using 15 new sample data, the test to get a successful outcome as much as 74.4% and 25.6% error. Based on the above experiments it can be concluded that the more training data, the success rate obtained will be higher. In addition to experimental testing of new data with training data, testing was also conducted on the application. To find success in detecting can be seen in the pattern output. Pattern output has been obtained from the input image. Part success output pattern can be seen in Table 3:

Table 3. Examples of Input Image by Pattern Output

Input Image	Pattern Output
<p>1 2</p> <p>·</p> <p>1</p> <p>·</p> <p>.. 4</p> <p>3 ..</p> <hr/> <p>1 2</p> <hr/> <p>3 4</p> <p>·</p>	<p>1 2</p> <p>1^</p> <p>1*</p> <p>.. 4</p> <p>3 ..</p> <p>{1 2}</p> <p>{3 4*}</p>

.  
1 2 3 4  
.  
{1^2} 3 4\*

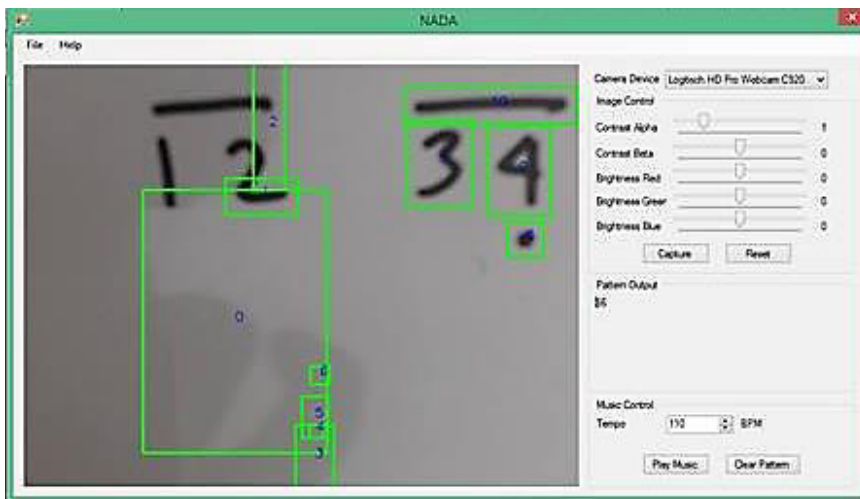


Fig. 3. There is A Shadow in The Image

In figure 3 there is a failure in detecting the symbol notation because the numbers are too dark and not pass control to reduce dark settings that exist in the image because of that the pattern output failed to read the symbol notation.

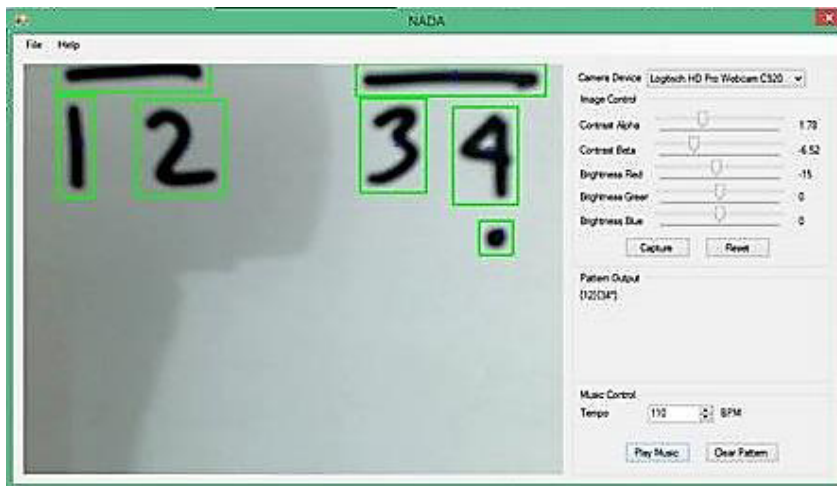


Fig. 4. Success Happens In Pattern Output

In figure 4 the output pattern owned in accordance with the results already exist image. To obtain the corresponding results then must remove noise by adjusting the control section and setting light to the image and click button play music to get melody piano also can change the BPM.

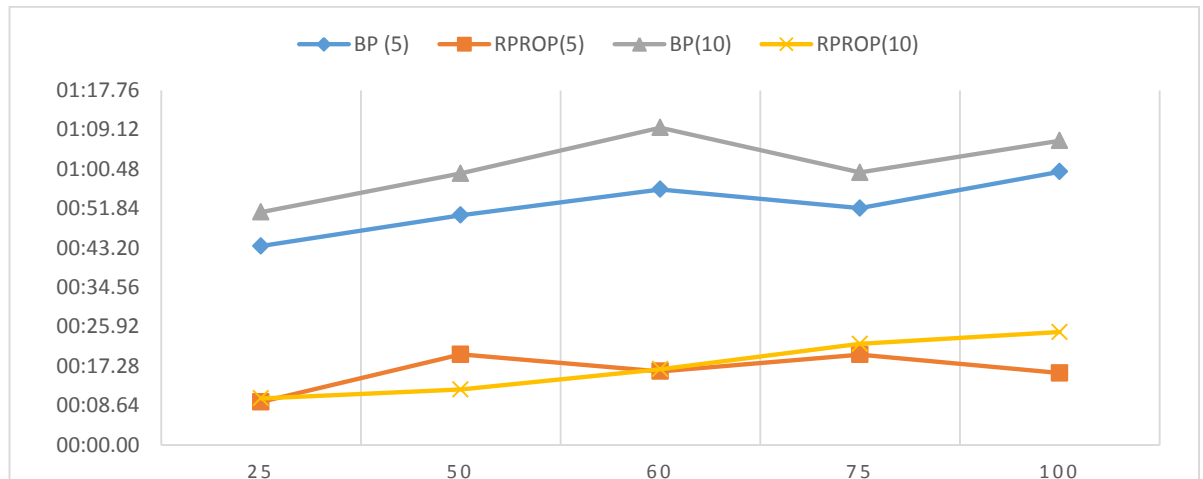


Figure 5. Time needed for training data between Backpropagation and Resilient Backpropagation

Figure 5 shows the time needed for training the data between backpropagation and resilient backpropagation from time training data on minute, second, and millisecond. Based on the research, we aim 5 and 10 target output from each backpropagation and resilient backpropagation. The result from time training data resilient backpropagation is faster than backpropagation.

#### 4. Conclusion and Suggestion

Based on the research, neural network techniques using resilient backpropagation algorithm for comparing training data and new data can be read from handwriting and by using colour filtering can reduce errors in handwriting recognition. In our analysis of resilient backpropagation algorithm has a speed in training data. Future work will be the development for additional symbols that are not used and can read the full notations.

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