BANKNOTES RECONITION SYSTEM

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Introduction

Prior to the adoption of banknotes and flat coins, Thailand used the shell, Baked Clay Coins, and Pot Duang as the money. The first Thai banknote is used since 1912. King Rama 5 had the policy to establish the banknotes. It leads to a growing economic system. People at that time can exchange the product and banknote as obviously. Thai banknotes are made from cotton fiber, not plastic. The reason why we aim to classify Thai banknote is helping an unknown person such as a foreigner. This tool can help them to classify in a few times.

This project focused on Thai Banknotes which used in King Rama 9, and 10. There are 5 focused types of banknotes which are 20, 50, 100, 500, and 1000. These banknotes have many styles. Therefore, this project will not use all style.

Consequently, the goal of this project is to classify Thai banknotes which one is 20, 50, 100, 500, and 1000 correctly by using a digital image processing method.

Literature Review

2017 - Banknotes detected using Image Processing Techniques
Researcher
H.Masoumi and N.Panah
Tool
MATLAB
Methodology
In this paper, an automatic system is proposed. This system consists of two steps. First, the banknote image in the input will be read by the RGB color model. Then, applying image processing techniques, they get a numerical model that is between 1 and 10. Second, the input banknote image is in black and white models. Then by applying some image processing techniques on the banknote image, the value of money will be determined.
Scope
Iranian banknotes
The Result
During this process, they managed to eliminate some of the photo noise of input banknotes. It should be noted that the proposed algorithm is very flexible and by working on it much more noise can be removed from the input photo.

2012 - Paper Currency Verification System Based on Characteristic Extraction Using Image Processing
Researcher
Rubeena Mirza and Vinti Nanda
Tool
LBP tool and MATLAB
Methodology
The approach consists of a number of components including image processing, edge detection, image segmentation, characteristic extraction, comparing images. The image processing approach is discussed with MATLAB to detect the features of paper currency.
Scope
Indian Paper Currency
The Result
Approach suggested from the beginning of image acquisition to converting it to grayscale image and up to the word segmentation has been stated. The work

will surely very useful for minimizing the counterfeit currency.

2017 - Currency recognition system using image processing
Researcher
Veda Samhita Abburu, Saumya Gupta, S. R. Rimitha, Manjunath Mulimani, and Shashidhar G. Koolagudi
Tool
Unknown
Methodology
This method works by first identifying the country of origin using certain predefined areas of interest, and then extracting the denomination value using characteristics such as size, color, or text on the note, depending on how much the notes within the same country differ.
Scope
20 banknotes in each country consist of Australian Dollars, Canadian Dollars, Chinese Renminbi, American Dollars, Danish Krone, Euro, Hong Kong Dollar, Indian Rupee, Indonesian Rupiah, Kuwaiti Dinar, Mexican Peso, Norwegian Kroner, New Zealand Dollar, Philippine Peso, Japanese Yen, Russian Rubles, Saudi Riyal, Singapore Dollar, Swiss Franc, and UAE Dirhams
The Result
They have found that our system is able to accurately recognize most of the countries and denominations correctly (93.3% accuracy, where accuracy is defined as the number of notes correctly identified divided by the total number of notes tested).

2015 - A High-Performance Banknote Recognition System Based on a One-Dimensional Visible Light Line Sensor
Researcher
Young Ho Park, Seung Yong Kwon, Tuyen Danh Pham, Kang Ryoung Park, Dae Sik Jeong, and Sungsoo Yoon
Tool
semidefinite programming
Methodology
An algorithm for recognizing banknotes is required in many fields, such as banknote-counting machines and automatic teller machines (ATM). Due to the size and cost limitations of banknote-counting machines and ATMs, the banknote image is usually captured by a one-dimensional (line) sensor instead of a conventional two-dimensional (area) sensor. Therefore, they propose in this paper a novel method for pre-classifying banknotes' direction for implementation in banknote recognition systems.
Scope
United State dollar
The Result
This report showed that the error rate for the proposed pre-classification method was lower than that of other methods. In addition, the banknote-recognition error rate after pre-classifying the banknote's direction was as low as 0.114%. However, incorrect recognition occurred when part of the banknote was damaged or when contaminants were present in the upper or lower region of the banknote.

2018 - Decision tree model for classification of fake and genuine banknotes using SPSS
Researcher
Akanksha Upadhyaya, Vinod Shokeen, and Garima Srivastava
Tool
The decision tree model is built using IBM SPSS tool.
Methodology
This paper proposes an effective predictive model based on a machine learning technique for authentication of banknotes, which can predict with good accuracy that whether the given banknote is fake or genuine.
Scope
Dutch, German, English, and US counterfeit banknotes
The Result
The model shows 91% of accuracy. This model can be used for the classification of fake and genuine currency of different

countries. The work can be extended by comparing this model with other predictive models for the calculated values of different currencies notes in terms of four independent variables mentioned in the paper.

2017 - Banknotes Recognition in Real Time Using ANN
A thesis submitted to School of Engineering, Computer and Mathematical Sciences, Auckland University of Technology by Yueqiu Ren.
Researcher
Yueqiu Ren
Tool
MATLAB
Methodology
BPMN Classifiers and other ANN classifiers
Scope
New Zealand banknotes including 5 NZD, 10 NZD, 20 NZD, 50 NZD, and 100 NZD
The Result
As the recognition results of 500 test images, with 100 test images for each class, the average F-measure of every combination is beyond 0.88 when using the banknote images captured by webcam for training, while not all the combinations can achieve this when using the scanned banknote images for training.

2016 - IMAGE PROCESSING BASED FEATURE EXTRACTION OF CURRENCY NOTES
Researcher
MOHAMMAD ARIF
Tool
MATLAB
Methodology
Direction (front, rotated front, back, and rotated back) and face value, neural network based bill recognition and verification method, the learning vector quantization (LVQ) method
Scope
Numerous Indian Currency notes of value 100
The Result
Approaches suggested from the beginning of scanning a document to converting it to binary image, thresholding, morphological filtering and word segmentation has been successfully stated In our current approach, the whole character itself was used as a feature. Selection of feature extraction method is the single most important factor in achieving high recognition performance.

2019 - Perfecting Counterfeit Banknote Detection - A Classification Strategy
Researcher
Malladi Tejasvi, A.Nayeemulla Khan, A.Shahina
Tool
Machine Learning
Methodology
detect portraits in the banknotes using CNN
Scope
1372 greyscale bank note images each of size 400x400 pixels
The Result
Perfect classification (100%) was achieved using ANN, SVM and KNN. The logistic regression followed by decision tree and simple perceptron have also performed well by detecting fake notes at 99.27%, 98.91% and 98.91% respectively.

2018 - Exploratory analysis for the identification of false banknotes using portable X-ray Fluorescence spectrometer
Researcher
M.A. Zamalloa Jaraa, C. Luízar Obregónb, C. Araujo Del Castilloa
Tool
portable X-ray Fluorescence spectrometer
Methodology
detect portraits in the banknotes using CNN
Scope
the 200 Nuevos Soles banknotes
The Result
The results from the semi quantitative elemental analysis, using pXRF, show that the chemical composition of the ink used

in the false banknotes is different to that of the original ones.

2018 - Analysis of Banknote Authentication System using Machine Learning Techniques
Researcher
Sumeet Shahani, Aysha Jagiasi, Priya R. L.
Tool
Machine Learning
Methodology
two supervised learning techniques
The Result
The results of training and test data do not show much difference except for sensitivity of SVM. The training sensitivity of SVM is 98.68% and the test sensitivity is 98.69%. BPN gives 100% detection rate and SVM gives 98.90% success rate.The result shows that back-propagation neural network outperforms support vector machine and gives 100% success rate.

Methodology

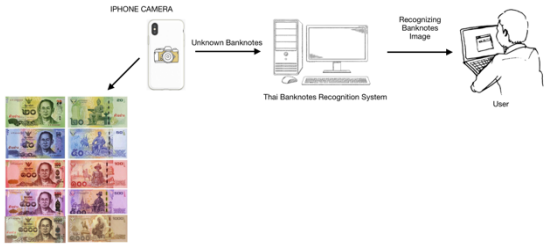

Figure 1: Conceptual Diagram

Structure Chart

Thai banknote recognition system consists of five main process modules:
1) image acquisition
2) image preprocessing
3) feature extraction
4) image recognition
5) result presentation

Image acquisition

The whole data which are images should be taken from bird-eye-views as input in this system. The banknotes have to set the same environment. While taking a picture, the mobile has to available a flashlight mode. All of the banknotes, which are a dataset, have to place in a horizontal line.

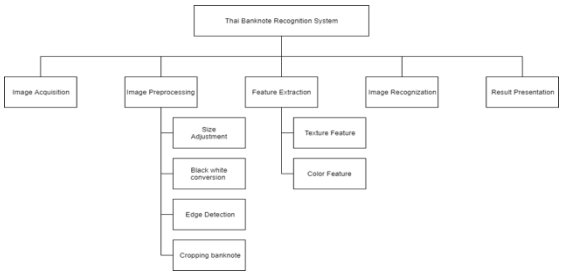

Figure 2: Structure Chart

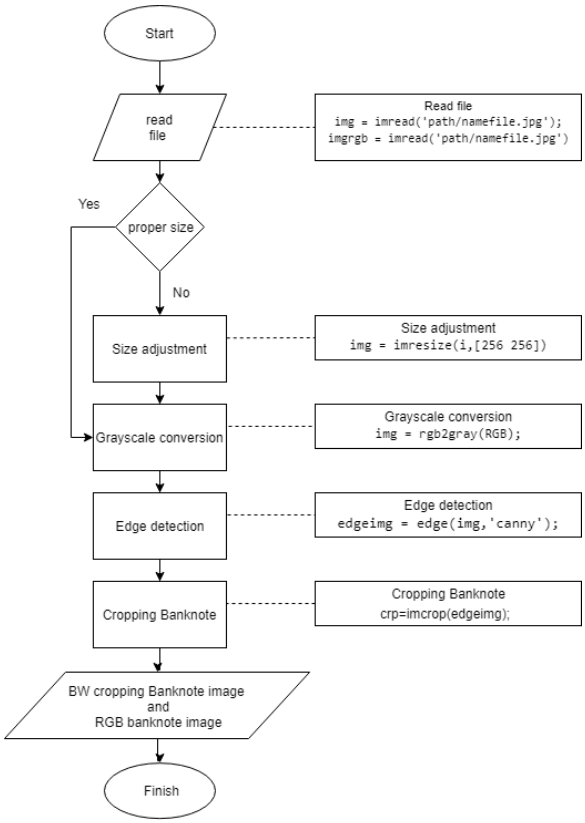

Figure 3: Image Preprocessing Chart

1. Size adjustment
After reading two files, if the picture is an incorrect size in case of images come from different devices, the picture will step in size adjustment process. This process will resize two photos to be the same size.

2. Grayscale conversion
Make one photo to be grayscale for using in texture feature. For the RGB picture, there's no need to step in this process because it will use in the color feature process.
3. Edge detection
After grayscale conversion, the next process is edge detection by using a candy filter because it is suitable for Sobel detection.
4. Cropping Banknote
The unwanted part of the image will be removed by this process. It will be left only the bank. Then the picture is ready to use in the image recognition process.

Feature extraction

There are two features that were used in the Thai Banknote Recognition System:
1. Texture feature
2. Color feature
The system will keep the mean color of each color into the excel file

Image Recognition

After preparing an excel file, there will be an image recognition method. The technique which this system used to compare two images is Euclidean distance. This is owing to a Euclidean distance formula can be used to calculate the distance between two data points in a plane. If the value is very few, it meant that two datasets are very similar as well. The equation is below in figure 4.

$$d(p,q) = d(q,p)$$
$$= \sqrt{(q_1 - p_1)^2 + (q_3 - p_3)^2 + \cdots + (q_n - p_n)^2}$$
$$= \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

Figure 4: Euclidean distance equation

Result Presentation

There will be 2 axes charts which are upload pictures and result in pictures. The edit bar which below those charts represents the name of the file. There are also 3 buttons which are the upload button, the train button, and the recognition button (test). As shown in figure 5.

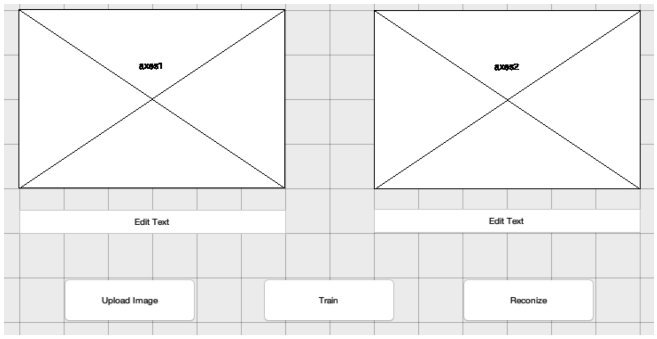

Figure 5: MATLAB result interface

Graphic User Interface

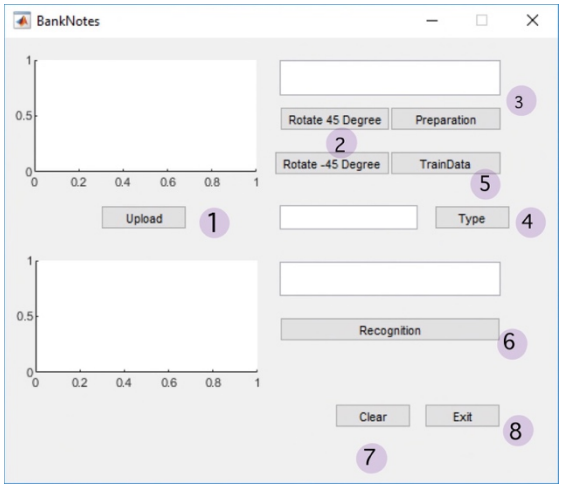

Figure 6: User Interface

Implementation

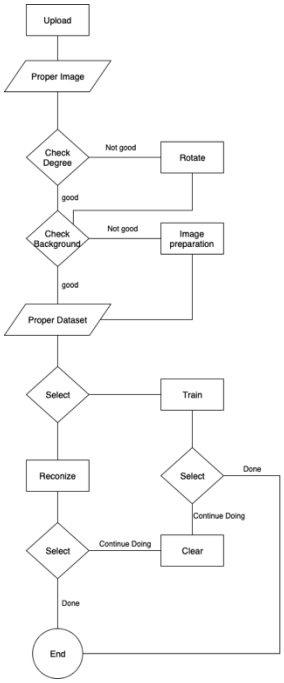

Figure 7: Flow chart of Implementation

1. Upload

```
global image;
global pic;
global filename;
image = strcat(pathname,filename);
pic = imread(image);

axes(handles.axes1); imshow(pic);
axes(handles.axes2); cla;

set(handles.edit1,'string',filename);
```

2. Rorate 45 or -45 degree

```
global pic

pic = imrotate(pic,45);

% imrotate(pic,-45)%
axes(handles.axes1); imshow(pic);
```

3. Preparation [Crop an object]

```
global pic;

hsvImage = rgb2hsv(pic);
sImage = hsvImage(:, :, 2);

mask = sImage > 0.1;
mask = bwareafilt(mask,1);
mask = imfill(mask, 'holes');

props = regionprops(logical(mask),
'BoundingBox');
croppedImage = imcrop(pic,
props.BoundingBox);

axes(handles.axes1);

imshow(croppedImage);
```

4. Color Recognition

```
global pic;

 r=mean(mean(pic(:,:,1)));
 g=mean(mean(pic(:,:,2)));
 b=mean(mean(pic(:,:,3)));
 Thou = abs(r-b);
 %Thou > 3 is not 1000%
 onethou = false;
 if Thou <=3
    onethou = true;
 end

 if (r > g) && (r > b)  && (onethou ==
false)
    set(handles.edit3,'string','100');
       elseif (b>r) && (b>g)&& (onethou
== false)
    set(handles.edit3,'string','50');
 elseif (g>b) && (g>r)  && (onethou ==
false)
     set(handles.edit3,'string','20');
       else
    set(handles.edit3,'string','1000 or 500');
 end
```

5. Preparing data for Euclidean distance Recognition [Train]

```
global pic;
global filename;
global excel;
excel =
'E:\MATLAB\R2018\bin\Project\DB_Trai
n.xlsx';

tab=xlsread(excel);
[rr,cc]=size(tab);
% ..... Calculate Features
 mred=mean(mean(pic(:,:,1)));
```

```
mgreen=mean(mean(pic(:,:,2)));
mblue=mean(mean(pic(:,:,3)));
gray=rgb2gray(pic);
mgray=mean(mean(gray));
%energy
gray=rgb2gray(pic);
glcm = graycomatrix(gray, 'o', [0,1]);
S = graycoprops(glcm);
energy = S.Energy*100;

%entropy
rngfil = rangefilt(pic);
entro = entropy(rngfil)*100;

%homo
Homo = S.Homogeneity*100;

%contrast
Contrast = S.Contrast*100;

%Correlation
correlation=S.Correlation*100;

% ..... calculate Excel Cell
cell1=cat(2,'A',num2str(rr+2));
cell2=cat(2,'B',num2str(rr+2));
cell3=cat(2,'C',num2str(rr+2));
cell4=cat(2,'D',num2str(rr+2));
cell5=cat(2,'E',num2str(rr+2));
cell6=cat(2,'F',num2str(rr+2));
cell7=cat(2,'G',num2str(rr+2));
cell8=cat(2,'H',num2str(rr+2));
cell9=cat(2,'I',num2str(rr+2));
cell10=cat(2,'J',num2str(rr+2));

% ..... Write Excel Data
xlswrite(excel,[{filename}],1,cell1);
xlswrite(excel,[mred],1,cell2);
xlswrite(excel,[mgreen],1,cell3);
xlswrite(excel,[mblue],1,cell4);
xlswrite(excel,[mgray],1,cell5);
xlswrite(excel,[entro],1,cell6);
xlswrite(excel,[energy],1,cell7);
xlswrite(excel,[Homo],1,cell8);
xlswrite(excel,[Contrast],1,cell9);
xlswrite(excel,[correlation],1,cell10);

system('taskkill /F /IM EXCEL.EXE');
```

6. Euclidean distance Recognition

```
global pic;
global excel;

excel =
'E:\MATLAB\R2018\bin\Project\DB_Trai
n.xlsx';
datasetpath
='E:\MATLAB\R2018\bin\Project\Dataset\
';

tab=xlsread(excel);
[rr,cc]=size(tab);

% ..... Calculate Features
 data(1)=mean(mean(pic(:,:,1)));
 data(2)=mean(mean(pic(:,:,2)));
 data(3)=mean(mean(pic(:,:,3)));
 gray=rgb2gray(pic);
 data(4)=mean(mean(gray));
 gray=rgb2gray(pic);
 glcm = graycomatrix(gray, 'o', [0,1]);
 S = graycoprops(glcm);
 rngfil = rangefilt(pic);
 data(5) = entropy(rngfil)*100;
 data(6) = S.Energy*100;
 data(7) = S.Homogeneity*100;
 data(8) = S.Contrast*100;
 data(9) =S.Correlation*100;

% ..... Matching
min=999;
rec=0;

for i=1 : rr
diff=0;
   for j=1 : cc
      diff=diff+sqrt(power(tab(i,j)-
data(j),2));
   end
if (diff <=100)
   min=diff;
   rec=i;
end
end

if (rec ~= 0)
   %found
  cellx=cat(2,'A',num2str(rec+1));
   %cellx = A3
  [~,ff]=xlsread(excel,1,cellx);
```

```
   file=ff{1};
   imgfile = strcat(datasetpath,file);
   result=imread(imgfile);
   axes(handles.axes2); imshow(result);
file= strcat('Found : ',file);
   set (handles.edit2, 'string',file);
else
    % not found
   fig=zeros(250,300);
   axes(handles.axes2); imshow(fig);
   set (handles.edit2, 'string','NOT
FOUND');
end
```

Filename	Red	Green	Blue	Gray	Entropy	Energy	Homogeni	Contrast	Correlatior
20-1.jpg	170.43579	171.34534	173.72782	171.33276	406.834	21.540698	94.437518	13.284939	94.75482
20-2.jpg	161.91586	164.08868	167.9865	163.8631	388.82578	23.041594	96.318451	8.4412394	96.018055
20-3.jpg	78.924137	79.843387	81.408513	79.73824	277.47092	31.587265	98.152747	5.5747542	99.519193
20-4.jpg	82.522364	83.364826	84.931448	83.273812	289.12584	31.104932	97.313681	8.2845608	99.35825
20-5.jpg	41.481576	41.724247	42.375568	41.725923	173.95517	58.238367	98.54271	4.6543623	99.499121
20-6.jpg	39.71663	40.171529	40.870544	40.114239	171.14495	58.342643	98.906235	3.4070944	99.596997
20-7.jpg	19.765121	20.050421	20.421973	20.005966	97.388676	77.338461	99.511025	1.5472084	99.68077
20-8.jpg	83.300565	83.218723	84.432449	83.382477	284.07619	31.225098	97.352569	8.2174736	99.36141
20-9.jpg	20.908214	21.005943	21.384715	21.018698	98.510912	77.32756	99.371671	2.1035932	99.612504
20-10.jpg	20.111366	20.175505	20.533888	20.193806	96.204648	77.344161	99.521857	1.5586992	99.683541
20-11.jpg	172.57138	171.71687	178.86304	172.79221	330.6906	24.654549	96.528839	8.1241527	96.514715
20-12.jpg	21.119833	20.907939	21.704103	21.057531	86.991085	77.369389	99.574139	1.4825671	99.724722
20-13.jpg	41.691304	41.557674	43.37087	41.796955	150.96564	58.399039	99.041126	3.2129533	99.652758
20-14.jpg	20.835251	20.734607	21.617026	20.862342	87.096149	77.352092	99.558771	1.4922498	99.719117
20-15.jpg	10.463915	10.436765	10.88871	10.495185	49.964124	88.212088	99.752851	0.8233139	99.712503
20-16.jpg	166.68339	163.96535	171.08512	165.56484	322.48987	23.375112	96.491555	8.4102519	96.148617
20-17.jpg	80.2326	79.36551	83.136724	80.047008	239.75675	31.533206	98.261747	5.5652429	99.531048
20-18.jpg	40.674506	39.977467	41.785125	40.38576	147.54537	58.354316	99.045947	3.3073333	99.618033
20-19.jpg	20.330123	20.011281	20.859985	20.202919	84.826887	77.347741	99.604457	1.4087959	99.717741
20-20.jpg	170.89802	169.66648	172.93162	170.37688	394.29463	20.874262	95.106632	11.347948	95.816672
20-21.jpg	165.01226	164.07982	168.12004	164.79596	377.81559	23.309298	96.746765	7.1141573	96.751745
20-22.jpg	80.878811	80.108206	81.842385	80.524653	272.38339	31.511179	98.26938	5.4115676	99.545088
20-23.jpg	40.541211	40.143573	41.069398	40.366192	161.9468	58.332463	99.112784	2.8252094	99.672515
20-24.jpg	10.031401	9.9819992	10.232941	10.024751	52.30556	88.207852	99.757865	0.7698993	99.704878
20-25.jpg	20.129961	19.996398	20.439969	20.08378	93.514673	77.334934	99.562382	1.4545648	99.703357
20-26.jpg	20.892301	20.696334	21.191676	20.810814	94.922548	77.330883	99.455288	1.7982577	99.658535
20-27.jpg	41.562864	41.393804	42.311625	41.541627	169.12806	58.208449	98.674284	4.1911324	99.543511
20-28.jpg	83.689042	83.225511	85.219254	83.57932	275.39864	31.149707	97.693183	7.1689938	99.447216
20-29.jpg	171.68503	169.78401	173.36982	170.75569	386.35283	19.915001	95.418191	10.582858	96.394821
20-30.jpg	165.52284	164.31901	170.18055	165.34648	384.78737	22.033849	95.276628	10.869935	95.164423
100-1.jpg	172.17725	160.27999	167.92779	164.68315	376.70378	23.913586	96.093739	8.9751159	95.625566

Figure 8: Data table from excel file

7. Clear a Data

```
axes(handles.axes1); cla;
axes(handles.axes2); cla;

set (handles.edit1,
'string','                    ');
set (handles.edit2,
'string','                    ');
```

8. Exit the System
Close

Experiment Result

Thai Banknote Recognition System can recognize banknotes by 2 techniques which are Color Recognition and Euclidean distance Recognition. The experiment uses 12 pictures for each type of bank from the internet. For color recognition technique, it can recognize all pictures including both match and not match. Another technique which is Euclidean distance recognition can find only 1 match from all 60 banknotes.

Type	Color Recognition			Euclidean distance Recognition		
Result	Match	Miss Match	Unknown	Match	Miss Match	Unknown
20 Baht	6	6	-	-	-	12
50 Baht	7	4	-	-	-	12
100 Baht	12	-	-	-	-	12
500 Baht	1	11	-	1	-	11
1,000 Baht	1	11	-	-	-	12

Figure 9: Result table from the experiment

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