Modified Chi-Square Distance to Improve Personality Type Recognition based on Handwriting

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ABSTRACT
This research was conducted to develop a mobile device that is able to recognize one's personality to support expert decisions based on handwriting through the application of graphology and enneagram psychology. In the process, handwritten data is processed in three main stages, namely pre-processing, texture feature extraction in the form of contrast, energy, and entropy with GLCM, and similarity measure through the modified chi-square method. The value of the feature is categorized into 4 categories in the form of slant, size, breaks and baseline, which will be stored in the SQLite database as a reference. Later, the determination of personality will be seen based on the calculation of the smallest distance of the test data on the reference value of the combination of the categories. Based on the results of the study, the three GLCM texture feature values obtained have intervals that are not unique, and difficult to distinguish between one personality type to another. But the use of the modified chi-square method in the form of random weights can process the feature values so that the test data can be distinguished by type personality with each other with a precision of 60-80% and an accuracy of 72%.

General Terms
Data Mining, Feature Extraction

Your general terms must be any term which can be used for general classification of the submitted material such as Pattern Recognition, Security, Algorithms et. al.

Keywords
Chi-square, Enneagram, GLCM, Graphology, Personality, Psychology

1. INTRODUCTION
Graphology is the study of how to recognize a person's character based on handwriting. The science is often called pseudoscience, because it is still doubtful and difficult to prove the truth of the results. In Indonesia, only one person has become a Graphologist, Deborah Dewi, who has received certification from the American Association of Handwriting Analyst (AAHA) and the American Handwriting Analysis Foundation (AHAF). This can be because the technique of reading characters from a handwriting in graphology is still quite difficult to interpret into computer technology. Another American graphology expert named Clifford Howard in [1], provides an explanation that the characteristics of a handwriting can describe many things about a person's nature and personality. Not only behavior, but psychological health, mental, strengths and weaknesses that exist in a person can be reflected in a handwriting. This is what the researchers then tried to develop and implement in the form of an android system to help facilitate the analysis of handwriting and their personality through the Grey Level Co-occurrence Matrix (GLCM) and modification of The Chi-Square Distance methods.

Research on graphology has basically been developed by several world researchers before. As in the research conducted by Coll R. et al in [2], it has succeeded in showing a link between handwriting and one's personality with an accuracy rate of 89% through Backpropagation Artificial Neural Network method. Similar research was also carried out by Kamath V. et al in [3], where this study resulted in an accuracy of 80% through the Image Processing and Trait Acquisition method after being compared with the results of manual analysis. While research related to handwriting analysis has also been carried out by researchers in research in previous years. In 2014 [4] researchers succeeded in developing software using the form feature extraction method that was able to read a person's personality based on handwriting judgements per word from each sentence, where the results provide an accuracy percentage of 63.3% and prove that the breaks feature is the most recognizable features visually and can be used as the main feature in handwriting. Then the research in 2016 [5] and 2017 [6] where researchers have succeeded in proving the correlation between the form of handwriting (the science of Graphology) and the personality or psychological condition of a person (Psychology) at 81.6% through the form-based feature extraction method and Enneagram. In addition, researchers have also carried out research on handwriting analysis for means of security or forensics graphology in 2016 [7][8] and 2017[9], which also uses methods for extracting features of the same shape, and inner methods product to determine the ownership or authenticity of a person's document with presentation accuracy achieved at 55% - 72%. From some of the results of this research, the researcher will redevelop the handwriting analysis application to support the personality test facility that can be used at any time by many parties through an Android device using the GLCM method.

Basically, Grey Level Co-occurrence Matrix (GLCM) is one method that can be used to analyze the texture of an object in [10]. This statistical-based technique has a very good ability in retrieving important information from a data, and has been widely implemented in various researches. As in Vargas study [11] which applied the GLCM and Local Binary Pattern (LBP) approaches to the signature verification application, and Babu in [12] with the same application through the GLCM method Support Vector Machine (SVM) it had good results with False Recognition the Rate (FRR) is only 10.35% to 32.51%. Based on the results of this research, the researchers will then try to apply the same method in the case of handwriting analysis, which will be expected by applying

the GLCM method to provide better results from previous year's research to help determine a person's personality based on his handwriting. With the existence of android device that will be developed in this study, it is expected to make it easier for interested parties such as HRD, psychotherapists, psychologists, graphologists in analyzing one's personality and also as a supporting tool for the decisions they make.

2. METHODOLOGY

In this study, some literature was used to support the methodology implemented, such as color conversion, thresholding, extracting features, pattern recognition, graphology, and psychology science.

A. Color Conversion

Color conversion is a part of the pre-processing stage, where this color chance will have an impact on the next process, for example in the pattern recognition stage. One color conversion procedure for RGB color image to greyscale which calculates the mean value of R (red), G (green), B (blue) may lose contrast, sharpness, shadow and structure of the color image. This impact requires the addition of missing values or by using the latest algorithm in the form of RGB approximation, reduction, addition and finance as Saravanan, C in [11] and Right, C. Cottrell GW in [12].

B. Thresholding

Thresholding is a technique that is generally used to separate an area significantly in order to obtain a better analysis. This technique can be applied with a single threshold or multi threshold. In Pratiwi et al's research [13] and this study, the applied thresholding uses a single threshold because the color characters in the data used do not have many features, namely 128 color values as the foreground (handwriting object) interval. The value determination has a model similar to Shapiro V et al's research in [14] but without weighting, with the following formula:

$$g_{mid}(R) = [g_{min}(R) + g_{max}(R)] / 2$$

$$g1(R) = \hat{g}, \text{ if } \hat{g} \in [g_{min}(R), g_{mid}(R)]$$

$$g2(R) = \hat{g}, \text{ if } \hat{g} \in [g_{mid}(R) + 1, g_{max}(R)]$$

The value of g is the color value, where $g1$ will be the foreground area, and $g2$ will the background area.

C. Feature Extraction

Feature extraction is an important stage of the application of pattern recognition and analysis. This stage will give results in the form of feature values that will be measured or recognized as patterns. With the extraction of features, important information from a data (which in this study is in the form of handwritten image data) will be retrieved and stored in feature vectors [14]. Features that can be extracted globally in image data include features in color, shape and texture. And in this research, the feature that will be extracted is based on handwritten texture representation using the Grey Level Co-occurrence Matrix (GLCM) method.

GLCM is a statistical method introduced by Haralick in 1973, where this method has the ability to extract important information in the form of textures from a data based on its probability value [10]. The co-occurrence matrix contains the value of distance and direction, where in image data can be expressed as a pixel value of the direction or coordinates *i* and *j*, namely *P(i, j)*. Haralick gives 14 parameters that can represent the texture value of an image, 3 main parameters include:

a) Moment of Inertia or Contrast (I)

The contrast value can represent the sharpness value in the image, where if the higher the contrast value, the sharper the object in the image.

$$I = \sum_{i=0}^{n} \sum_{j=0}^{n} |i-j|^2 P(i,j)$$

b) Energy (E)

The value of energy can represent the value of roughness and softness in the image, where if the higher the value of energy, the more rough the object that is in the image, and vice versa.

$$E = \sum_{i=0}^{n} \sum_{j=0}^{n} P(i,j)^2$$

c) Entropy (H)

The entropy value can represent the irregularity value in the image value [14]. This value can also measure the amount of texture information in the image [10].

$$H = -\sum_{n} p(f_n).Log_2 p(f_n)$$

D. Pattern Recognition

Pattern recognition is one of the techniques of Artificial Intelligence (AI) that aims to recognize features or special characteristics of a set of data (both text and image documents) and classify them [15]. Pattern recognition can be done in several ways, one of them is by using the Similarity Measures method. Similarity measures is a method that can be used to find similarities from one object to another, through calculating distance [16]. There are many ways to calculate distances, such as through the *Manhattan Distance* formula, *Euclidean Distance*, *Chi-square Distance*, and *Cosine Distance*. In this study, distance calculation is done by applying the Chi-square distance method, which is modified by adding random weight (*w*) to clarify the difference in distance obtained:

$$x^2 = \sum_{i=0}^{n} \frac{(H_i.w - S_i.w)^2}{H_i.S_i}$$

Where x is the value of the chi-square distance, H and S are the variable values in the H and S object.

Chi-square is a simple method that can measure the similarity between objects, based on statistical probability values in [12]. Chi-square is also the right method for analyzing correspondence or data correlation between several variables (more that 2 variables) or multivariate. The variables in this study will be in the form of handwriting characteristic determinants according to graphology which correlate with their personality types, namely slant variables, size, baseline (flat line) and breaks (pause).

E. Graphology

Graphology is a study of the technique of reading human character through handwriting from various perspectives [1]. Research on graphology has been widely used to help find out a person's personality and character. In providing analysis, graphology has several reading angles from the categories of handwriting forms, such as writing slope, pressure, size, and

writing distance [17]. Each category of handwriting has a different analysis of personality and character.

F. Psychology

Psychology is defined as a scientific study of the behavior and mental process of an organism [18]. In 'scientific' meaningful study is carried out and data collected follows a systematic procedure, namely using a psychological test. Psychological testing is a structured technique used to produce one example of selected behavior. An example of this behavior will be used to draw conclusions about the psychological attributes of a person [18].

In previous research, researchers have succeeded in proving the correlation between the character of handwriting forms and one's personality based on the results of enneagram mapping [6]. Here is the table:

Table 1. Personality and Handwriting Characteristics Mapping.

Category	Shape	Personality
Slant	Left	Depressed emotions, hiding, closed, self-awareness, inner rebellion, quiet, selfish, anxious, difficult to understand, not independent, difficult to get along with, rarely show real feelings or desires, oriented in the past, emotionally cool but can still be seen socializing, it's hard to accept progress or change.
	Vertical	Analytical, independent, full of consideration, use logic rather than emotion, his attitude is not explosive, and not flashy, often it has a personal charm that attracts people to get close to it.
	Right	Open, demonstrative, sympathetic, emotional, sentimental, fanatical, irresponsible, easily show feelings, oriented in the future, his feelings will influence his decision, sincerely in touch
Baseline	Up	Restless, easily exploded, unrealistic, ambitious, optimistic active
	Down	Moody, too sensitive, depressed, easily broken hearted, melancholy
	Flat	Clever self-control, stable, reliable, firm
Size	Large	Thinking of himself as very important, expansive, extroverted, like to be extravagant, likes to be heard / watched, like being noticed, requires recognition, enjoy attention, don't like being alone. Can be assertive, enthusiastic and optimistic, but also able to be excessive, restless, and lack concentration and lack of discipline.
	Medium	Can adapt to conventional circumstances or circumstances that have strong influence that require adaptation and balance of mind, practical, realistic.
	Small	The ability to concentrate, simple, introverted, careful, critical of himself, not looking for spotlight / attention and not to communicative, except with close friends, have a good academic mentality, simple, sometimes feeling inferior, can organize well, details, do not care about what others think.
Breaks	Dashed	It depends on instinct and intuition, is open to other people's thoughts and feelings, independent, individualistic, relax, extrovert, inconsistent, moody, restless, shy, selfish, can't adapt, very good observer, inventive and inspiring thinking, have a great imagination, fast understanding.
	Connected	Relying on logic with careful conclusions, self-understanding, reliable, consistent, be careful, introverted, logical, rational, analytical, systematic thinking, and always planning ahead, don't like being interrupted, diligent and tenacious, often nervous, love reading and learning, nice to look for and want change.

This mapping then will be used again to determine the psychological condition as well as one's personality from the writing character produce by each test data.

3. DATA COLLECTION

Data collection in this study will be carried out through direct search of a handwriting collection from a number of sources, or from several graphological books with handwritten reference complete with personality assessments. Each of these handwritten documents will be processed in digital form through a scanner, which will then produce handwritten data in the form of JPEG images. The amount of data that will be used as a reference is training data, later depending on the results of the consistency of expert analysis on the characteristics of written data based on 4 categories of each author. Where in this study, 250 data were collected from 50 authors (5 written samples from each author, with different time taking data). Analysis of data characteristics that have no change (consistent) carried out by graphology experts, then the data is used as a reference in reading new data

characteristics. Here is a sample of data:

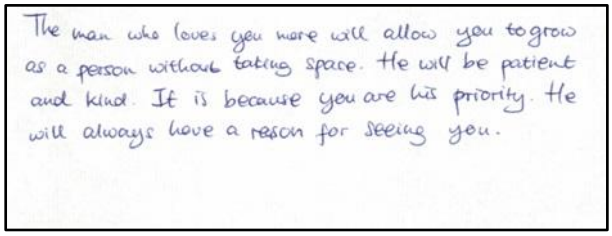


Fig 1: Handwritten Data Sample

4. EXPERIMENTAL RESULTS

From the analysis conducted by graphology experts on 250 handwritten data from 50 authors, the consistency of writing characteristics was obtained by 210 data, of which the remaining 40 data had different analysis results, both for slant, size, baseline, or breaks characters. Factors that influence the difference in this analysis can be due to the intentional side of the author (psychologically, for example being in a hurry, lazy to write, or other) or the assessment of experts who see a change in writing. This difference will be captured as an error, so that the data will not be used as a reference feature in analyzing the characteristics of new writing.

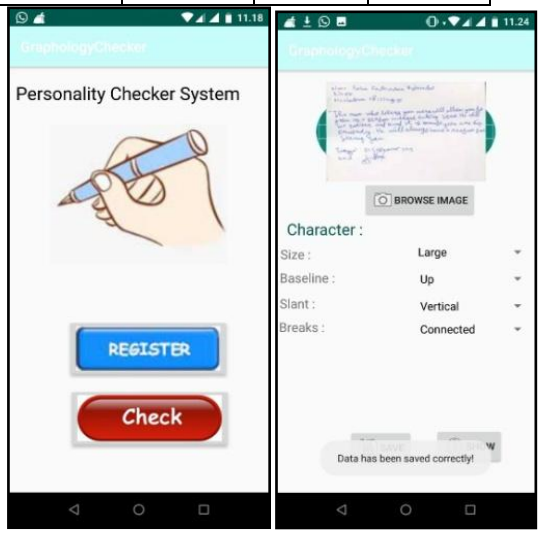
The following is feature reference table along with enneagram mapping based on the results of reading systems and graphologian expert analysis as well as psychologists from this study:

Table 2. Handwriting Characteristics and Feature Value Mapping

No	Base-line	Slant	Size	Breaks	Enneagram Type	Contrast	Energy	Entropy
1	Up	Left	Small	Dashed	4	0.51032	0.0871	0
2	Up	Left	Small	Connected	5	0.30255	0.0633	-0.106
3	Up	Left	Large	Dashed	8	0.92422	0.08104	0
4	Up	Left	Large	Connected	7	1.13829	0.05802	-0.0153
5	Up	Left	Medium	Dashed	4	0.51139	0.03142	-0.0311
6	Up	Left	Medium	Connected	5	0.73888	0.07820	-0.0042
7	Up	Vertical	Small	Dashed	6	0.32894	0.08226	0
8	Up	Vertical	Small	Connected	5	1.13211	0.05770	0
9	Up	Vertical	Large	Dashed	7	0.58477	0.05165	-0.0791
10	Up	Vertical	Large	Connected	8	0.56616	0.05099	0
11	Up	Vertical	Medium	Dashed	3	0.34221	0.06904	-0.0155
12	Up	Vertical	Medium	Connected	5	0.31163	0.04821	0
13	Up	Right	Small	Dashed	7	0.30557	0.07302	-0.0239
14	Up	Right	Small	Connected	3	0.58110	0.08428	-0.011
15	Up	Right	Large	Dashed	3	0.42445	0.06700	0.0631
16	Up	Right	Large	Connected	1	0.50821	0.05583	-0.0442
17	Up	Right	Medium	Dashed	6	0.30123	0.07238	-0.0315
18	Up	Right	Medium	Connected	3	0.52098	0.05707	0
19	Flat	Left	Small	Dashed	4	0.37399	0.06392	-0.0177
20	Flat	Left	Small	Connected	6	0.82933	0.05783	0
21	Flat	Left	Large	Dashed	8	1.14228	0.07537	0
22	Flat	Left	Large	Connected	9	0.83722	0.05622	0
23	Flat	Left	Medium	Dashed	6	0.28384	0.07023	0
24	Flat	Left	Medium	Connected	6	0.38302	0.06140	-0.0021
25	Flat	Vertical	Small	Dashed	4	0.76085	0.06008	0
26	Flat	Vertical	Small	Connected	5	0.52534	0.07025	0
27	Flat	Vertical	Large	Dashed	3	0.42088	0.07228	-0.0841
28	Flat	Vertical	Large	Connected	1	0.31388	0.05923	-0.0102
29	Flat	Vertical	Medium	Dashed	6	0.83400	0.06781	-0.0176
30	Flat	Vertical	Medium	Connected	7	0.42988	0.04588	0

31	Flat	Right	Small	Dashed	6	0.58221	0.08031	-0.0339
32	Flat	Right	Small	Connected	9	0.67252	0.07502	-0.0215
33	Flat	Right	Large	Dashed	7	0.49772	0.06736	-0.0124
34	Flat	Right	Large	Connected	1	0.21373	0.05892	0
35	Flat	Right	Medium	Dashed	3	1.13521	0.06830	-0.0408
36	Flat	Right	Medium	Connected	1	0.68200	0.07201	-0.0195
37	Down	Left	Small	Dashed	4	0.82033	0.05992	-0.0142
38	Down	Left	Small	Connected	6	0.91892	0.06834	-0.0174
39	Down	Left	Large	Dashed	8	1.15289	0.07241	-0.0242
40	Down	Left	Large	Connected	6	0.52930	0.05931	-0.0923
41	Down	Left	Medium	Dashed	8	0.48352	0.05789	0
42	Down	Left	Medium	Connected	6	0.73002	0.06821	-0.0156
43	Down	Vertical	Small	Dashed	2	0.94113	0.07089	-0.0883
44	Down	Vertical	Small	Connected	9	1.10353	0.08057	0
45	Down	Vertical	Large	Dashed	7	0.50242	0.05538	0
46	Down	Vertical	Large	Connected	5	0.62072	0.06780	0
47	Down	Vertical	Medium	Dashed	2	0.54211	0.04233	-0.0125
48	Down	Vertical	Medium	Connected	9	0.50785	0.04716	0
49	Down	Right	Small	Dashed	4	0.52993	0.05729	0
50	Down	Right	Small	Connected	6	0.78322	0.08351	-0.0121
51	Down	Right	Large	Dashed	6	0.37942	0.03589	0
52	Down	Right	Large	Connected	8	0.52104	0.06305	-0.0311
53	Down	Right	Medium	Dashed	6	1.14517	0.05008	0
54	Down	Right	Medium	Connected	8	1.02683	0.08307	0

Based on the results of characteristics of the handwriting form by dividing 4 categories (11 sub-categories) which appear in table 2, the personality type of the enneagram that has the most unique characteristic of writing form is personality type 2 or "Helper" type because there are only two categories of characteristics only *down-vertical-small-dashed* and *down-vertical-medium-dashed*. While the personality type is not the most unique because it has 13 categories of character forms of writing namely personality type 6 or "Observer" (The Investigator). The following is the display of the system that was built:



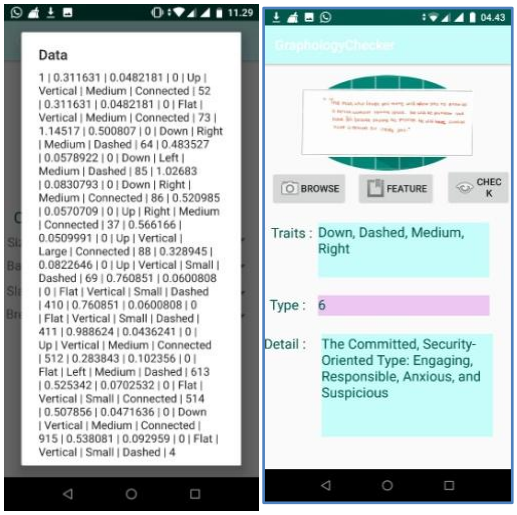


Fig 2: Display of System

Based on the feature reference data that has been obtained from Table 2, then the final test is carried out on new research data totaling 50 data (research data obtained in 2015) which have know the personality type from expert graphology and psychology to match the results with the system.

Table 3. Personality Type Result of 50 New Data

No	New Data (Owner)	Personality Type	
		Expert Result	System Result
1	Marcella	3	5
2	ANONYMOUS	3	4
3	Nathania	9	6
4	ANONYMOUS2	5	5
5	ANONYMOUS3	5	5
6	ANONYMOUS4	3	3
7	ANONYMOUS5	9	9
8	ANONYMOUS6	2	2
9	ANONYMOUS7	4	4
10	ANONYMOUS8	4	4
11	Zilzikridini	4	9
12	Veni Emiriya	3	3
13	Yayang Nafisa	7	7
14	Vitria R Claudia	9	9
15	Nadine A.S	7	5
16	Sarah	3	3
17	Titania Raras N	4	4
18	Khumaira A.	6	6
19	Tara Ayu A.P	9	8
20	Niken	7	7
21	Nurul Mulya P.	9	9
22	Putri	3	3
23	Labiba	7	7
24	Melinda	9	7
25	Nur Fajriyah	7	5
26	Tiara	7	7
27	Ranyta Diani	5	5
28	Sarah Widiyanti	6	6
29	Lady Margaretta	2	2
30	Rania Bahasoean	9	9
31	Sisilya Eva	7	7
32	Safira	5	5
33	Nissa	1	1
34	Ari Satria	8	1
35	Robert Muliawan	5	2
36	Tiffany Marcelline	2	4
37	Tiffany	9	9
38	Qotrunnadya	9	9
39	Siti Salediah	2	2
40	Namira	6	7
41	Petra Mario S.	2	2
42	Lea Insani	5	5
43	Marcellina	7	7
44	Sherli Betris	1	1
45	Viola	2	2
46	Shazlin	1	5
47	Manindya	9	5
48	Miranti V	8	8
49	Stella Febrina	7	7
50	RM	3	3

From the results of trials on mobile application built by testing new data as much as 50 data (Table 3), obtained a match of 36 data between the results of expert analysis with system analysis, with the percentage obtained at 72%. This percentage can be said to be quite good because the system works with the results of reading personality type not much different from expert judgment. For assessment from experts, there can be differences in analysis in reading the handwritings of the same authors, of which from 5 handwritings from the same authors, 1 or 2 handwriting have different analysis results or a precision level of 60-80%. Therefore, the use of the modified Chi-square and GLCM method in this study can be concluded to be quite appropriate because it is successful in recognizing one's character and personality from handwriting, which is capable of producing analyzes that are not much different from psychology or graphology experts. So the system built can be said to be able to be used to support the decisions of psychologists and other interested parties in determining, detecting and assessing a person's personality.

5. CONCLUSIONS

The conclusions that can be drawn from the research are:

a) Texture values of handwritten data consisting of contrast, energy and entropy are able to represent quite well the characteristics of the handwriting from used in this study in the form of slant, size, breaks and baseline.

b) The GLCM feature values in the form of contrast, energy and entropy obtained have intervals that are not unique, and difficult to distinguish between one personality type to another, but using the Chi-square method that is modified adding random weights is able to process the value of the feature so that the data testing can be distinguished from each other's personality type.

c) Mapping 9 personality types from texture values based on the GLCM method obtained through reference to 210 data with a precision of 60-80%, capable of producing personality recognition quite well. This can be seen from the results of testing new data that have not too much difference between the assessment of experts or psychologists with the system built.

d) The use of the modified Chi-square and GLCM methods in this study can be concluded to be quite appropriate because it is successful in recognizing a person's character and personality from 50 handwritten data tested with a percentage of 72% accuracy.

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