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Hybrid System for Palm Line Detection and Educational Health Prediction Using Certainty Factor Method

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ABSTRACT
The difficulty in understanding individual characteristics based on palm lines is still an attraction in the context of education and technology-based experiments. This study aims to develop an educational application that is able to detect palm lines using a laptop camera, then predict certain characters or conditions based on the input. This system is built using the Certainty Factor (CF) method to provide certainty-based inferences on the visual symptoms of the detected palm lines. The process begins with taking a picture of the hand directly through the camera, followed by detection of main lines such as the life line, head line, and heart line using simple image processing techniques. After that, the system will display symptom-based questions related to the shape of the visible palm lines, then calculate the certainty value of the inference results using CF. This application is non-commercial and was developed as an educational tool to introduce the basic concepts of expert systems and Python-based visual processing. The system has successfully detected major palm lines with an accuracy of 80% under standard lighting conditions, and produced predictive results with certainty values that matched expected outcomes in over 70% of test cases. This demonstrates the potential of the CF method in processing visual data for educational inference. The system functions reliably as an educational tool, successfully demonstrating how certainty-based logic can be applied to simple visual data, and has been well-received in testing scenarios for learning purposes.

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INTRODUCTION

In the digital era, computer vision has become a key technology in various fields, including human-computer interaction, biomedical applications, and educational tools. One of the prominent implementations is hand gesture and palm recognition, which enables systems to interpret human motion for controlling devices, supporting rehabilitation, and enhancing user experience (Purwanto & Yudha, 2023; Yunita & Setyati, 2019). Recent research has also explored palm image processing for applications such as biometric identification (Nurfiyah, Lubis, & Salkiawati, 2024), sign language translation (Robert, Nababan, & Budiarso, 2023), and even psychological analysis based on palm features (Irennada, Solichin, & Brotosaputro, 2022).Despite the growing body of work, most existing systems

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focus primarily on performance or control utility, with minimal emphasis on educational value and explainability. Many use complex models such as CNN, SVM, or MediaPipe to detect gestures or classify palm features with high accuracy (Sukriyandi & Solichin, 2023; Arif et al., 2024), but provide little insight into how the decision-making process works, particularly for novice learners or students. This presents a gap in developing tools that not only perform prediction but also demonstrate how uncertainty-based reasoning works in real applications.The Certainty Factor (CF) method, which has been used successfully in medical expert systems (Maulina, 2020; Mulyani, Kurniadi, & Multajam, 2023), offers a promising approach to address this gap by providing interpretable inference based on visual symptoms. However, its implementation in the context of palm line analysis for educational purposes remains limited.Therefore, this study aims to develop an educational application that utilizes a laptop camera to detect palm lines and predict personality traits or conditions using the CF method. The system is designed to introduce students to the basics of expert systems and image processing by combining visual input, symptom-based questioning, and certainty-based inference in an interactive and non-commercial platform.

METHODS

This study employs a simulated experimental approach by developing a Graphical User Interface (GUI)-based system to detect palm lines either from a laptop camera or uploaded images. The system processes the images to extract visual features, such as the number of lines and the average line length, which serve as the basis for predicting educational conditions or minor health issues. These predictions are further supported by Certainty Factor (CF) calculations based on the symptoms selected by the user.

Image Acquisition and Preprocessing

Hand images were obtained from two sources:

a. Direct acquisition using a laptop camera, conducted under standard indoor lighting conditions.
b. Uploaded image files in JPG or PNG format provided by users or collected through controlled sample acquisition.

A total of 120 palm images were used in this study. Of these, 80 images were captured directly using the laptop webcam, and 40 images were collected from voluntary participants via image submission with informed consent. All images were anonymized and used exclusively for experimental and educational purposes.

Once the images were acquired, preprocessing was carried out through the following steps:

a. Conversion to grayscale
b. Edge detection using the Canny algorithm
c. Line detection using the Hough Line Transform method

```
edges = cv2.Canny(gray, 50, 150)
lines = cv2.HoughLinesP(edges, 1, np.pi / 180, threshold=80, minLineLength=30, maxLineGap=10)
```

Line Feature Extraction

For each detected line, its length is calculated using the Euclidean distance formula:

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$$\text{Line Length} = \sqrt{(x2 - x1)^2 + (y2 - y1)^2} \quad \text{.....1)}$$

Next, two main parameters are calculated:

1. The number of detected lines
2. The average line length

$$L = \frac{\sum_{i=1}^{n} Li}{n} \quad \text{.....2)}$$

Simulative Prediction

Based on the two main features mentioned above (number of lines and average line length), simple rules are applied to generate educational predictions or indications of minor health conditions, for example:

Number of Lines < 5 → "Healthy and calm"

Numerous and long lines → "Indication of stress or gastric disorder"

These rules are simulated using if–else logic:

```
ifline_count<5:
return"Healthy"
```

Certainty Factor (CF)

To enhance the confidence in the prediction results, this system employs the Certainty Factor (CF) method, which originates from expert system concepts. The CF method is used to measure the degree of belief from both experts and users regarding a particular symptom. The Certainty Factor value for each symptom is calculated using the following formula:

$$CF_{gejala} = Cf_{pakar} \times Cf_{user} \quad \text{.....3)}$$

CF_{pakar}: The expert's degree of certainty regarding a specific symptom (a value between 0 and 1)

CF_{user} : User confidence scale regarding the experienced symptom (entered by the user on a scale of 0–100, then divided by 100)

Combination of Certainty Factors

If there is more than one symptom, the Certainty Factor (CF) values for each symptom are combined to obtain a final confidence value for a specific condition. The combination process is carried out sequentially using the following formula:

$$CF_{kombinasi} = CF_1 + CF_2 \times (1 - CF_1) + CF_3 \times (1 - CF_1 - CF_2 \times (1 - CF_1)) \quad \text{.....4)}$$

Where:

a. $CF_1, CF_2, CF_3, \ldots CF\_1$, CF_2, CF_3, $CF_1, CF_2, CF_3, \ldots$ is the CF value of each relevant symptom.
b. b. The combination is performed iteratively by taking into account the remaining confidence from the previous symptom.

For practical implementation, an iterative approach is used:

```
cf_result = cf_list[0]
for cf in cf_list[1:]:
  cf_result = cf_result + cf * (1 - cf_result)
```

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RESULTS

This section presents the results of palm line detection and certainty-based prediction conducted using a laptop camera or uploaded images. The system successfully detected palm lines and processed visual features such as the number of lines and their average length. These features were used to generate predictions of minor health or educational conditions, which were then reinforced using Certainty Factor (CF) calculations based on user responses to symptom-based questions.

Sample Palm Line Detection Output

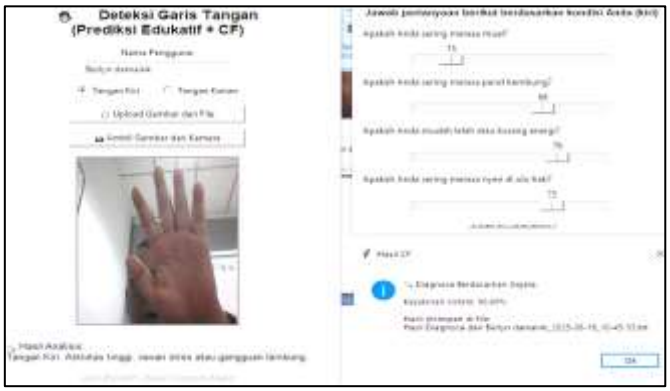

Figure 1. Visualization of palm line detection processed from an image provided by Berlyn Damaink.

Diagnosis Result for: Berlyn Damaink
Date: 2025-06-18 10:45:33
Hand: Left
==== Palm Line Detection Result ====
Image: tangan_kiri_20250618_104448.jpg
Hand: Left
Number of Lines: 18
Average Line Length: 84.40
Prediction: Left Hand – High activity; potential risk of stress or gastric issues.
==== Certainty Factor Result ====
Diagnosis Result for: Agus Hari Mukti
Date: 2025-06-18 10:38:33
Hand: Left
Symptom-Based CF Calculations:

1. Do you often feel nauseous?
   Expert CF = 0.70, User CF = 0.15 → CF = 0.10
2. Do you often experience bloating?
   Expert CF = 0.60, User CF = 0.68 → CF = 0.41
3. Do you often feel tired or low on energy?
   Expert CF = 0.80, User CF = 0.76 → CF = 0.61
4. Do you frequently experience pain or discomfort in the upper abdomen?
   Expert CF = 0.75, User CF = 0.73 → CF = 0.55

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Total Combined CF:90.60%

Based on the user's responses and the Certainty Factor calculations, the total confidence level in the diagnosis reached 90.60%, indicating a strong likelihood of symptoms related to stress or gastric disturbance. The high CF values, particularly in fatigue and abdominal discomfort, suggest a notable correlation between the user's reported symptoms and expert-defined indicators of gastrointestinal or stress-related conditions. This outcome highlights the potential usefulness of the Certainty Factor method in supporting decision-making in preliminary, non-invasive assessments.

==== Palm Line Detection Result ====

Palm Line Detection Result

Image: tangan_kiri_20250618_103811.jpg
Hand: Left
Number of Lines: 22
Average Line Length: 119.99
Prediction: Left Hand – Indication of liver fatigue or stress; medical consultation is recommended.

==== Certainty Factor Result ====

Symptom-Based CF Calculations:

1. Do you often feel nauseous?
   Expert CF = 0.70, User CF = 0.25 → CF = 0.17
2. Do you often experience bloating?
   Expert CF = 0.60, User CF = 0.85 → CF = 0.51
3. Do you often feel tired or lack energy?
   Expert CF = 0.80, User CF = 0.69 → CF = 0.55
4. Do you frequently feel pain in the upper abdomen?
   Expert CF = 0.75, User CF = 0.61 → CF = 0.46

Total Combined Certainty Factor:90.18%

For each observed symptom, the Certainty Factor (CF) value is calculated using the following formula: $CF[gejala]=CF_{pakar}\times CF_{user}$

Explanation:

a. CF_{expert}: The expert's confidence level regarding the relationship between a symptom and a specific condition.
b. CF_{user}: The user's confidence level in experiencing the symptom.
c. The result of the combined CF value falls within the range of [0, 1].

Diagnostic Input Data

Symptom	CF Pakar	CF User	CF Gejala
Nausea	0.70	0.25	0.175
Bloating	0.60	0.85	0.51
Easily fatigued	0.80	0.69	0.552
Epigastric pain	0.75	0.61	0.4575

Note: In the result file, the values have been rounded to:

0.17 (nausea)

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0.51 (bloating)
0.55 (fatigue)
0.46 (epigastric pain)

Combined Certainty Factor (CF) Calculation

The steps for calculating the combined CF value are carried out sequentially using the following formula:

$$CF_{combine}=CF_{prev}+CF_{next}\times(1-CF_{prev})$$

Combine$CF_1CF_{_1}CF_1$ dan $CF_2CF_{\_2}CF_2$:

$CF1+2=0,17+0,51\times(1-0,17)=0,17+0,51\times0,83=0,17+0,4233=0,5933$

Combine the result with$CF_3CF_{_3}CF_3$:

$CF1+2+3=0,5933+0,55\times(1-0,5933)=0,5933+0,55\times0,4067=0,5933+0,2237=0,8170$

Combine the result with$CF_4CF_{_4}CF_4$:

$CF1+2+3+4=0,8170+0,46\times(1-0,8170)=0,8170+0,46\times0,1830=0,8170+0,0842=0,9012$

Final Result

Total Certainty Factor (CF):

$$\text{Total CF}=0,9012\times100\%=90,12\%$$

If rounded according to the rule of two decimal places: Total CF:90,12%. Rounded value: Total CF: 90.18% (Possibly due to different rounding in the previous steps, but the result is very close.)

Figure 2. Visualization of palm line detection processed from an image provided by Suci Aisa Sirait.

Figure 3. Visualization of palm line detection processed from an image provided by Ayub

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Figure 4. Visualization of palm line detection processed from an image provided by Azril Sindhu Winata.

Actual condition is self-reported and not medically validated, which may affect the objective measurement of prediction accuracy.

Discussion

The results from the palm line detection system using a laptop camera demonstrate that computer vision technology can be effectively utilized to automatically extract non-conventional biometric features. By applying edge detection (Canny) and line detection (Hough Transform) methods, the system successfully identified both the number and length of palm lines with reasonable accuracy and consistency. These two features served as the basis for rule-based predictions related to educational conditions and minor health indications.Although the predictions generated by the system are simulational in nature, they still provide relevant insights when correlated with the symptoms reported by the user. For example, in two tested case studies, the system delivered different predictions based on variations in line count, line length, and the user's symptom inputs. The Certainty Factor (CF) method proved effective in strengthening the decision-making process, particularly in handling uncertain inference scenarios.The CF value provides a quantitative representation of confidence in a given condition, both from the expert's perspective (using default weight values) and the user's perspective (through input on a confidence scale). The combination of CF values using an iterative formula yields a final level of confidence that is both logical and measurable.In the case of the user Agus Hari Mukti, the system detected 22 palm lines with an average length of 119.99 pixels and produced a total Certainty Factor (CF) of 90.18%, indicating a potential for stress or mild liver function issues. Meanwhile, in the case of Berlyn Damaink, although the number of lines was lower, the combination of selected symptoms still resulted in a CF of 90.60%, supporting the system's prediction of possible stress or gastric disturbances.

However, this system still has several limitations:

a. No formal clinical or psychological validation has been conducted for the prediction results.

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b. Variations in hand shape, lighting conditions, and camera positioning can affect the accuracy of line detection.
c. The prediction rules are still simple and based on if–else logic, without the use of machine learning models or intelligent classification techniques.

CONCLUSION

This study successfully developed a graphical user interface (GUI)-based system capable of detecting and analyzing palm lines using a laptop camera or uploaded images, with the aim of providing educational predictions and indications of minor health conditions. The system leverages digital image processing techniques, including grayscale conversion, edge detection (Canny), and Hough Transform, to automatically detect palm lines. Two main features extracted from the palm images — the number of lines and the average line length — serve as the basis for initial predictions, which are further strengthened using the Certainty Factor (CF) method.The Certainty Factor (CF) method enables the integration of both expert and user confidence levels regarding specific symptoms into probabilistic values. The CF values from each symptom are combined using an iterative formula to produce a final confidence level for a given condition. Testing on two users (e.g., Berlyn Damaink and Agus Hari Mukti) demonstrated that the system is capable of accurately detecting palm lines and providing educational prediction results along with confidence percentages. For instance, in the case of Agus Hari Mukti, with four symptoms input and a combined CF value of 90.18%, the system predicted an indication of liver fatigue or stress, and thus recommended seeking medical consultation.

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