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Application of The Speed-Up Robust Features Method To Identify Signature Image Patterns On Single Board Computer

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Abstract

Through the development of a signature pattern recognition program on SBC Beagle-bone Black, this research seeks to determine how to differentiate between real and false signatures. Three techniques of gathering data were employed in this study: interviews, observations, and a review of the literature. The quick application development method is the approach that is applied. The rapid, efficient, and brief development cycle (RAD) is emphasized. This study uses a use-case diagram to illustrate the application's logic and data flow. In this study, OpenCV is used as a digital image processing library along with the C++ programming language and QT creator as an integrated development environment (IDE). This application was subjected to both accuracy and functional testing. The following conclusions are drawn from the findings of the investigation and testing that was done: Using the fast library approach for approximate nearest neighbors (FLANN) and the speeded-up robust features (SURF) feature extraction method, the signature pattern recognition program on the Beagle-bone black SBC can differentiate between real and fraudulent signatures. Through the processes of generating image scale space, feature localization, and feature description, the SURF approach extracts feature from signature images. This signature pattern recognition application is one of the digital image processing apps that can be run on the Beagle-bone Black single board computer. This indicates that the specifications of the SBC Beagle-bone Black for digital image processing are good.

Keywords: Pattern Recognition, Speeded-Up Robust Features, Digital Image Processing.

1. Introduction

A signature is a biometric system that is included in the behaviometric category because its creation is very influential on the habit of writing with a pen. The signature is one part that confirms the authenticity of the signature maker (authentication). Signatures play an important role in authentication in financial, commercial, and official transaction processes. Distinguishing between genuine and fake signatures is not easy. Currently, validation of signatures still uses conventional techniques, namely, observing them with the naked eye with a small probability of truth [1]. Today's digital image processing technology can take over this task. With digital image processing, the signature image can be extracted into numeric form, and the validity of the signature can be analyzed. According to research conducted by other parties, the probability of the correctness of digital signature image processing is currently almost close to ninety-nine percent. Bureaucratic reform has been implemented within the LIPI Physics Research Center (P2F) since 2013. Bureaucratic reform is intended as an effort to improve and change governance, organization, management, and sustainable resource management. Bureaucratic reform requires all environments to provide services quickly, precisely, and transparently. To support this, efforts are being made to digitize activities. What digitalization means is that all secretarial activities are carried out using information systems [2].

The function of signatures as authentication is still not replaced. This signature is used as a sign of attendance, delegation of authority, budget submissions, permits, and almost all other secretarial activities. This makes signatures the only security system that guarantees the authenticity and correctness of the information conveyed. The presence of an application that can recognize signatures to ensure the security of this information is very necessary [3]. When analyzing digital images, an extraction method is needed to obtain the expected features and characteristics [4]. Currently, there are many methods to obtain these features, including SIFT, SURF, ORB, BRISK, and many others [5]. This research uses the SURF method as an ecstasy method because, according to previous research, SURF has the advantage of speed in terms of feature search, resistance to scaling, transition, and rotation, and resistance to noise of a certain size [6]. The development of digital image processing technology is now starting to collaborate with single-board computer (SBC) technology. SBC has data processing capabilities like a stand-alone computer in general [7]. SBC also has a small and light shape, so its mobility level is very high. Collaboration between digital image processing and SBC enables digital image processing that is power-efficient and has a high level of mobility, making it very possible to create signature pattern recognition applications based on embedded systems [8]. It is hoped that this application will be able to answer the needs regarding security systems in the secretariat. Applications in the realm of computing are programs or a set of programs containing instructions or orders for the computer to do something [9]. A program describes separate instructions, which are usually called source code, created by application developers. According to this definition, an application is code that is transformed into a computer program that contains commands that function to carry out various forms of work or certain tasks, such as applying, using, and adding data [10].

In the beginning, the signature was in the form of a regular written name, so that it could clearly be read without an explanation of the name underneath, and now many people still sign like that. Over time, the signature took on its own form, all of which was created freely by the author himself [11]. There are forms of decoration, forms of beauty, brevity, and other additional attractions, according to one's desires and sense of beauty. Definitively, a signature is the result of a person's writing process, which has a special character as a symbolic substance. Signatures are the most widely used form of person identification. Signature is a biometric system that comes from behavioral habits (behaviometric traits). Signature is the authentication system most widely accepted by the public. Based on the verification method, signatures are divided into two categories, namely: Verification methods using static data acquisition are also called offline methods [12]. Static methods perform data acquisition after the writing process has been completed, or possibly even long after the writing process has been carried out. A person writes their signature on paper, which is then converted into a digital image using a scanner [13]. From this image, it is then processed to determine whether the signature is authentic or not. The signature verification method with dynamic data acquisition is also called the online method. In this method, the data acquisition process is carried out simultaneously with the writing process [14]. The data taken generally varies, not only in the form of the coordinates of the position of the writing point but also other dynamic information such as pressure, speed, hand pressing force on the pen, and so on. The type of data that can be retrieved depends greatly on the capabilities of the input equipment used. The input equipment that is often used to acquire data dynamically is called a digitizer [15].

Images captured by machines are represented as digital images using a sampling and quantization technique. Quantization indicates the size of the brightness level (grayscale) based on the amount of binary bits in the machine that produced the image, whereas sampling indicates the size of the boxes stacked in rows and columns (pixels). Digital image processing is a system in which an image is used as input and output, both of which are images. At first, image processing was done to enhance image quality [16]. However, as computing technology advanced as evidenced by computers' growing power and speed and by the development of computational sciences, which allow people to extract information from images, image processing and computer vision became inextricably linked. Keypoints from an image are used in the feature detection process called Speed-Up Robust Features (SURF) [17]. The actual components of an image or picture that have a strong or constant value in conditions of scale, rotation, blurring, three-dimensional transformation, lighting, and shape alterations are known as keypoints. This form shift may be the result of imperfect or partial shape in the original data image or sample image. A test image that is incomplete could have been captured with an imperfect camera, have another object hiding it, or the thing itself has altered in condition [18]. The SIFT approach was developed into the SURF method. The objective of both techniques is the same: to use scale space representation to detect local features. D. G. Lowe published a journal article titled "Distinctive Image Features from Scale-Invariant Keypoints" in 2004 that introduced the SIFT technique. The SIFT approach has limitations in terms of speed when it comes to identifying local features, despite being regarded as a trustworthy technique for doing so [19]. And the SURF approach complements that deficiency. Blob identification based on the Hessian matrix determinant and an integral image algorithm are combined in the SURF approach [20].

The pixel region surrounding the keypoint is used to determine the description. This descriptor depicts the intensity distribution of neighboring pixels around the keypoint, much to the gradient data produced by SIFT. Unlike SIFT, SURF calculates the first-order Haar wavelet response distribution in both the x and y directions without the need of gradients [21]. Additionally, SURF uses integral imaging to increase processing speed. This aims to reduce computing time for feature extraction and the feature matching process, which has also been proven to increase robustness [22]. First, the orientation that results is matched using data from the pixel's keypoint, the circular area surrounding the pixel. The SURF descriptor is then extracted from the box-shaped region that has been created in the chosen orientation [23]. The feature matching procedure between the two photos is executed in the following step. We will go into more depth about the two steps that are listed below for calculating keypoint descriptors [24]. A library for quick, approximative neighbor searches in high-dimensional space is the fast library for approximate nearest neighbors (FLANN) technique. The nearest neighbor values can be found using the techniques in this library, although the data utilized will determine the best parameter outcomes. Since signatures are a component of the biometric system, testing with biometric standards are used to evaluate the accuracy of the system to that of

other biometric systems. It is referred to as the false rejection rate (FRR) and the false acceptance rate (FAR) in the biometric system. The percentage of system faults in accepting (accepting) access to valid or invalid input is known as the false acceptance rate (FAR), while the percentage of system mistakes in rejecting (rejecting) access to valid or invalid input is known as the false rejection rate (FRR) [25].
An API (application programming interface) library that is well-known in computer vision image processing is called OpenCV (open source computer vision). The area of image processing known as computer vision is what gives computers the ability to perceive like people. In this scenario, computers are able to perceive objects, decide what to do, and act [26]. Face identification, face detection, face/object tracking, road tracking, and other applications are examples of computer vision implementations. An open-source C/C++ library for computer vision is called OpenCV [27]. OpenCV features strong image and video acquisition capabilities and is optimized for real-time applications. Because OpenCV is a library published under an open-source BSD license, users are able to use it for commercial purposes without having to disclose the source code. On Windows, Linux, Mac OS, iOS, and Android operating systems, OpenCV additionally supports the C++, C, Python, and Java programming languages. The goal of this research is to make signatures more secure so that consumers can tell the difference between real and false signatures [28]. In the long term, this research can be applied to other products such as attendance machines based on signatures, remote signatures, security applications using signatures, and many other things. It is hoped that signatures, as part of an easy-to-use biometric system, will continue to maintain their existence. It is also hoped that this research will be an inspiration for the use of SBC as a multifunctional device that can continue to be developed [29]. Digital image processing using SBC allows the birth of more functional computer vision technology such as facial recognition, fruit type recognition, vehicle recognition, and many other things.

2. Research Methods

Data collection is intended to search for and collect data related to research, such as theoretical basis, writing methodology, process methodology, and references for similar research. In this research, the data collection methods used were a literature study, interviews, and observation. Rapid application development (RAD) is the application development methodology that is employed. One incremental (multilevel) technique in the software development process model is called rapid prototyping, or RAD. Rapid, accurate, and brief development cycles are the focus of RAD. In this requirement planning phase, researchers collect and analyze all things that constitute the scope of application development. Researchers collected data by observation and literature review to find out how it works, its development, and the advantages and disadvantages of the system as it is for validating the signatures used. This stage produces documentation regarding the application requirements to achieve its functionality. Planning requirements that have been documented in the previous stage are presented in the form of visual modeling. This phase is carried out as a reference for the next phase. The visual modeling referred to at this stage is a diagram that explains the flow of data and logic and how the interface of the application will be built. In explaining the flow of data and logic in the application, this research uses use-case diagrams to describe user needs in the application and flow diagrams to explain events that occur in the application. In the construction phase, coding is carried out at this stage, namely translating the diagram modeling and design into commands that can be carried out by the computer. This research uses the C++ programming language with QT Creator as an Integrated Development Environment (IDE) equipped with OpenCV as a digital image processing library. Two tests were carried out on this application: functional testing and accuracy testing.

3. Results and Discussion

A total of 200 signature images were collected and subjected to a scanning process to obtain digital images. Scanning was carried out with a Canon Lide 25-type scanner with a resolution of 300 dpi. Next, the digital image is equalized to a size of 250 x 150 pixels. Pre-processing is also carried out on the signature image in the form of removing the background color. This process is carried out so that the feature search process in the next process produces detailed features. One of the shortcomings of signatures is that they are unique, because sometimes someone's signature is a different size (scale). The creation of a scale space is intended to make the signature image invariant to scaling. Creating a scale space for a signature image begins by comparing the scale of the signature image. This process is called image pyramiding. To get to the top of the pyramid, the signature image is first sub-sampled and then smoothed using a Gaussian function. A number of levels make up the scale space; the first level is the filter response, which convolves the input image with progressively larger filters. Keypoint locations are found using the Hessian-Affine region detector method, which is part of the SURF technique. Finding the Hessian threshold value to ascertain the keypoint position is the next step. The image's contrast level is taken into account while determining the threshold value. If the contrast value of the image exceeds the set threshold, the keypoint is obtained. Therefore, fewer keypoints are identified the higher the threshold value that is chosen. The Hessian threshold value of 400 is applied in this case. The Hessian value is used because the input image used is a signature image with a white background color; this makes the contrast of the image good enough to determine the keypoint. After determining the Hessian value, the next step is to determine the keypoint candidates. Determining this

keypoint candidate uses a non-maximum suppression process. The process involves comparing each image pixel in scale space with 26-Neighbors, which consists of 8 points in the original scale and 9 points in each upper and lower scale.
The Fast Library for Approximate Nearest Neighbors (FLANN) technique is utilized in this application to match features between two distinct signature photos. The OpenCV library already has a function for this algorithm. The FLANN function is made up of three functions: radiusSearch, which performs a search index, kknSearch, which locates K-dimensional nearest neighbors, and index, which creates a kd-tree search from found keypoints in a dataset. The index and kknSearch functions are employed in this instance. The features of the reference image and the number of kd-tree-forming parameters that is, the number of kd-trees you wish to form must be entered into a matrix in order for the index function to function. Meanwhile, the knnSearch function requires input in the form of features from the test image, the number of nearest neighbor points, and search parameters in the form of the maximum number of leaves examined in the search. The process that occurs in feature matching is the formation of a matrix containing features from the reference image and the test image. Next, the kd-tree is formed from the reference image features with the provision of several random kd-trees. Then the nearest neighbor search begins for the features of the test image. The output form of this feature matching is a feature index, which is the nearest neighbor and the distance between features. The feature is said to be suitable if the Euclidean distance ratio is 0.4.
This signature pattern recognition application was successfully built on a Beaglebone Black Single Board Computer with the QT C++ framework and the OpenCV digital image processing library. The application runs fine on the SBC Beaglebone Black. All functions can work well, and the user interface displays appropriate output. Testing was carried out to determine the accuracy of the application in recognizing signature image patterns. The false acceptance rate (FAR) (2) and false rejection rate (FRR) (1) are determined by testing. The application's failure rate in identifying the original signature image is measured by the false rejection rate (FRR), whereas the application's failure rate in rejecting phony signatures is measured by the false acceptance rate (FAR). It was found that the system error in accepting genuine signatures (FAR) was 20%, and the system error in rejecting fake signatures (FRR) was 30%.

From the series of studies above, the results obtained are that this signature pattern recognition application can functionally run well without any problems on the Beaglebone Black SBC. However, in terms of accuracy, this application still shows shortcomings. From testing the accuracy of this application, the error rate for both FAR and FRR is still high. The FAR value obtained from testing is 20%, and the FRR value is 30%. This error value is very likely to increase if testing a large amount of test data. When compared with other similar studies, previous research conducted using the SIFT method showed a FAR value of 14% and an FRR of 18%. In theory, the SURF method is the result of the development of the SIFT method. The SURF method emphasizes speed in searching for digital image features without compromising search accuracy. The results found during testing stated that there were many application errors in the feature matching process. This feature matching error occurs if a feature in the reference image is considered the same as a feature in the test image but has a different feature location. This error has the effect of increasing the distance value, which is the difference between the two signature images. Another error found by the author in this application lies in the non-optimal training process for the original signature image. The signature image training process in this application only weights the distance results from comparing the original signature image with other original signature images. This results in a training process that is not optimal. The author suggests further research using artificial neural network methods so that the training process produces more optimal values. In general, the lack of accuracy is due to the author's coding not being good enough so that the feature search and matching method does not work as it should.

4. Conclusion

The following conclusions are drawn from the findings of the investigation and testing that was done: Using the Fast Library technique for Approximate Nearest Neighbors (FLANN) and the Speeded-Up Robust Features (SURF) feature extraction method, the signature pattern recognition application on the Beagle-bone Black SBC can differentiate between real and false signatures. Through the processes of generating image scale space, feature localization, and feature description, the SURF approach extracts feature from signature images. This stage makes SURF a feature extraction method that is invariant to scaling, transition, and rotation. The nature of features that are invariant to scales and transitions is considered suitable for identifying signatures that have low consistency. However, the rotation-invariant nature of features can create errors in feature matching. The Beagle-bone Black SBC test results for the signature pattern recognition application showed false acceptance rate (FAR) of 20% and false rejection rate (FRR) of 30%. The Beagle-bone Black Single Board Computer is capable of running digital image processing applications such as this signature pattern recognition application. This means that the SBC Beagle-bone Black has good specifications for digital image processing. There are several suggestions from the author so that this research can be continued and provide better results, namely: Building a signature recognition application on the SBC Beagle-bone Black with an input process in the form of a dynamic signature (online signature validation). Improve the signature image training process and the feature matching process by using a method that is more specific to signature images. The author suggests using artificial neural network methods for the signature image training process. Carry out testing with more test data and differentiate the data between signature forgeries, skilled forgeries, and random forgeries.

References

[1] Bhavana, D., & J.L. Kalyan. (2023). Signature Security System in Banking Aplication. *International Jurnal of Science and Research (IJSR).*

[2] Haq, M. Z., Hendrawan, N., Mubarak, R., & Suarnatha, I. P. D. (2023). The Implementation of Simple Additive Weighting Method for Designing A Web-Based Waste Management Saving Transaction System. *Jurnal Sistim Informasi dan Teknologi*, 155-161.

[3] Ngemba, H. R., Nursalim, N., & Habibu, R. (2015). Model Inferensi Sistem Pendukung Keputusan Pathway Klinik Asuhan Keperawatan Bronchopneumonia. In *Seminar Nasional Informatika Medis (SNIMed)* (pp. 1-10).

[4] Pahlawansah, H., Octiva, C. S., & Muafiqie, H. (2023). Measurement Analysis of the Level of E-Commerce Adoption Readiness in SMEs Using Technology Readiness Index Method. *Jurnal Sistim Informasi dan Teknologi*, 193-197.

[5] Lumingkewas, C. S. (2016). Analisis Yuridis Pemaknaan Konsep Dalam Pasal 16 Undang-Undang Rumah Susun Bagi Masyarakat Berpenghasilan Rendah. *Arena Hukum*, *9*(3), 421-441.

[6] Lumingkewas, C. S., Nimran, U., Raharjo, K., & Utami, H. N. (2019). Effect of Job Insecurity to Organizational Commitment and Intention to Leave. *Wacana Journal of Social and Humanity Studies*, *22*(4).

[7] Sukmawati, E., ST, S., Keb, M., Fitriadi, H., Pradana, Y., Dumiyati, M. P., ... & Kasmanto Rinaldi, S. H. (2022). *Digitalisasi sebagai pengembangan model pembelajaran*. Cendikia Mulia Mandiri.

[8] Arta, D. N. C., Tannady, H., Fitriadi, H., Supriatna, D., & Yuniwati, I. (2023). Analisis Pengaruh Pelatihan Kerja Dan Rekrutmen Terhadap Kinerja Karyawan Di Perguruan Tinggi. *Management Studies and Entrepreneurship Journal (MSEJ)*, *4*(1), 587-596.

[9] Fitriadi, H. (2021). Pengaruh Suasana Resto Dan Kualitas Pelayanan Terhadap Kepuasan Pelanggan Pada Lan's Resto Dan Cafe Lahat. *Jurnal Teknik Ibnu Sina (JT-IBSI)*, *6*(02), 88-103.

[10] Fachrurazi, H., MM, S. A., Cahyadi, N., S ST, M. M., Fitriadi, H., Rianda Hanis, S. E. I., ... & Ak, M. (2022). *Dasar dan Konsep Manajemen Organisasi*. CV Rey Media Grafika.

[11] Sudyana, I. N., Kurniawati, H., Susanto, R., Dulame, I. M., & Vanchapo, A. R. (2023). The Effectiveness Analysis of Using Angle Puzzle Tools on the Achievement of Students' Learning Outcomes. *Journal on Education*, *6*(1), 1743-1748.

[12] Fadlilah, S., Setiawan, D. I., Murdhiono, W. R., Wiyani, C., Mindarsih, E., Lustiyati, E. D., & Susanto, R. (2022). The Anxiety Facing the 1st Dose of Covid-19 Vaccination and Related Factors. *International Medical Journal*, *29*(1).

[13] Fadlilah, S., Setiawan, D. I., Muflih, M., Amigo, T. A. E., Susanto, R., & Pujianto, A. (2022). Factors Associated with Adverse Events Following the First Dose of COVID-19 Immunization in Indonesia. *Korean Journal of Adult Nursing*, *34*(3), 249-257.

[14] Astuti, E. D., Susanto, R., Cahyono, D., Sudirman, S., & Astuti, M. T. (2023). The Effect of Problem Based Learning Work Sheet Usage on Student Learning Outcomes. *Mudir: Jurnal Manajemen Pendidikan*, *5*(2), 404-408.

[15] GS, A. D., Andarmoyo, S., Surya, S., & Susanto, R. (2022). Public Therapeutic Communication Analysis on Kanker_Fighter's Instagram Account. *Jurnal Komunikasi Profesional*, *6*(6), 557-572.

[16] Sutrisno, S., Tannady, H., Ekowati, D., MBP, R. L., & Mardani, P. B. (2022). Analisis Peran Kualitas Produk Dan Visual Identity Terhadap Purchase Intention Produk Teh Dalam Kemasan. *Management Studies and Entrepreneurship Journal (MSEJ)*, *3*(6), 4129-4138.

[17] Abdurrahim, A., Tannady, H., Ekowati, D., Nawarcono, W., & Pratomo, A. B. (2023). Analisis Peran Harga, Variasi Produk Dan Kualitas Produk Terhadap Customer Satisfaction Produk Konveksi. *Journal of Economic, Bussines and Accounting (COSTING)*, *6*(2), 1302-1307.

[18] Heryadi, D. Y., Ekowati, D., & Chusumastuti, D. (2023). Pengaruh Kehadiran Media Sosial, Orientasi Pasar Terhadap Kinerja UMKM di Jawa Barat. *Jurnal Bisnisman: Riset Bisnis dan Manajemen*, *5*(1), 94-107.

[19] Ekowati, D., & Subekti, I. (2022). Analisis Beban Kerja Dan Kebutuhan Tenaga Pramubakti Dengan Metode Work Sampling Dan Metode Workload Indicator Staff Needes. *Kajian Ekonomi dan Bisnis*, *17*(1), 31-44.

[20] MAMUSUNG, R. T., NIMRAN, U., SUHARYONO, S., & KUSUMAWATI, A. (2021). The Effect of Relationship Marketing on Service Quality and Customer Loyalty: An Empirical Study in Indonesia. *The Journal of Asian Finance, Economics and Business (JAFEB)*, *8*(7), 533-543.

[21] Mamusung, R. T., Kusumawati, A., Nimran, U., & Suharyono, S. (2019). Building Customer Loyalty through Service Quality and Customer Trust. *Wacana Journal of Social and Humanity Studies*, *22*(4).

[22] Mamusung, R. T., & Rasjid, E. Pengaruh Komitmen Perusahaan Terhadap Loyalitas Pelanggan Supermarket di Kota Manado. *Jurnal Administrasi Bisnis*, *9*(1), 71-80.

[23] Pramudito, D. K., Mursitama, T., Abdinagoro, S. B., & Tanuraharjo, H. H. (2021). THE INFLUENCE OF BIG DATA RECOMMENDATION: AN APPROACH ON E-LOYALTY OF E-GROCERY BUSINESS. *Psychology and Education*, *58*(2), 3550-3564.

[24] Pramudito, D. (2021). The Moderation Effect of e-Trust and Big Data Quality in e-Grocery: An Empirical Research from Outside of Java Island. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(10), 6445-6459.

[25] Pramudito, D. K., Nuryana, A., Assery, S., Purnomo, H., & Bakri, A. A. (2023). Application of Unified Theory of Acceptance, Use of Technology Model and Delone & Mclean Success Model to Analyze Use Behavior in Mobile Commerce Applications. *Jurnal Informasi Dan Teknologi*, *5*(3), 1-6.

[26] Pramudito, D. K. (2022). Data Mining Implementation On Java North Coast Weather Forecast Dataset Using C4. 5 Algorithm. *Jurnal SIGMA*, *13*(3), 139-148.

[27] Rembulan, G. D., Akhirianto, P. M., Priyono, D., Pramudito, D. K., & Irwan, D. (2023). Evaluation and Improvement of E-Grocery Mobile Application User Interface Design Using Usability Testing and Human Centered Design Approach. *Jurnal Sistim Informasi dan Teknologi*, 41-45.

[28] Pramudito, D. K., Ginting, R. U. B., Sekianti, A., & Baresi, I. S. (2023). Analysis of E-Commerce User Acceptance of Technology-Based Loan Application Features Using The UTAUT Model. *Jurnal Informasi dan Teknologi*, *5*(3), 36-42.

[29] Tania, K. D., & Aniarti, M. A. (2020). Tatto Regognition Based on Speeded-Up Robust Features (SURF). *Risalah Lokakarya Komputasi dalam Sains dan Teknologi Nuklir*, 123-140.