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RESEARCH ARTICLE

COMBINED FINGERPRINT MINUTIAE EXTRACTION USING FPGA

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ABSTRACT

Nowadays Automated Fingerprint Identification systems are most widely employed in verifying / identifying the physiological characteristics of individuals. The traditional privacy algorithms are inefficient to ensure security as there is more chance of duplicating the single fingerprint. So to enhance security in this work, a system is proposed which advocates acquisition of two fingerprint images (from that of thumb and index finger) from a single individual. From the Acquired image, minutiae points from thumb finger and the orientation angle from the index finger are extracted. The combined minutiae template is generated by detecting the reference points from each which is used in Reconstruction Technique. The, generated template is stored in a Database. In the authentication, the system requires two query fingerprints from the same two fingers which are used in the enrollment. Matching Process is done by calculating feature distance of the two query fingerprints. Combined minutiae template is similar to the original minutiae template; it is difficult to distinguish both the template by the attacker.

INTRODUCTION

Biometrics is for identification or distinguishes humans by their physiological characteristics or behavioral traits. Fingerprints are the most widely used physical parameter for identification amongst all biometrics like face recognition, DNA, Palm Print, hand geometry, iris recognition, retina. A fingerprint consists of ridges and valleys on the surface of a finger. A ridge is defined as a single curved segment, and a valley is the region between two adjacent ridges. Minutiae points are the local ridge discontinuities, which are of two types: ridge endings and bifurcations. A good quality image has around 40 to 100 minutiae. Biometrics can be used to determine and verify person's identity without their knowledge. Biometric authentication process involve in the comparison of registered and enrolled fingerprint samples. Fingerprint matching depends on ridge structures; the quality of the fingerprint image is of critical importance. But, ridge structures of a fingerprint image may get corrupted due to elements of noise while captured by a sensing device. This corruption is due to variations in skin and impression conditions such as scars, humidity, dirt, and non-uniform contact with the fingerprint capture device. Many algorithms (Smith ?; Miller ?; Wang ?; Kaufman 1995; Yorozu *et al.*, 1982; Young 1989; Duncombe 1959; Chen 1993; Lucky 1965; Bingulac 1994; Faulhaber 1995; Doyle 1987) have been proposed for minutia analysis, fingerprint matching and classification for better fingerprint matching. Recently, techniques (Juette and Zeffanella 1990; Kreifeldt 1989; Williams 1993; Kawasaki 1993) have been proposed that use other features apart from minutiae for fingerprint matching. Chen *et al.* (1993); Juette and Zeffanella (1990) (propose to reconstruct the fingerprint's orientation field from minutiae points and the reconstructed image is used in the matching stage to improve the system's performance. Kawasaki (1993) proposed a new technique which includes ridge features like ridge count, ridge length, ridge curvature direction and ridge type together with minutiae to increase the matching performance. There are a number of instances in the literature (*IEEE Criteria for Class IE Electric Systems* 1969; *Letter Symbols for Quantities* 1968) where evolutionary algorithms are used for matching minutiae of a fingerprint with that of a database of fingerprint images. The results of all such techniques depend on the quality of the input image. Thus, image enhancement techniques are often employed to reduce the noise and to enhance the definition of ridges against valleys so that no spurious minutiae are identified. In fact, matching latent fingerprints from crime scenes is difficult because of their poor quality and the fingerprint matching accuracy is improved by combining manually marked minutiae with automatically extracted ones (Haskell and Case 1994). In order to improve the personal security protection of fingerprint becomes an important issue. Conventional methods are not satisfied for the protection of fingerprint because decryption method is needed before the matching process. Existing techniques uses pseudorandom number (Key) for privacy protection. But this became vulnerable when the key and the protected fingerprints are stolen by attackers. Introduce a new method by combining two different fingerprints into a new

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identity. This identity is created by extracting minutiae points from two fingers. However this method became failure because the new identity contains more number of minutiae points compare to original fingerprint. So it is very easy for the attacker to identify the new identity.

fingerprint template. Extracted information will be matched with the stored database by using fingerprint matching techniques. The authentication will be successful if the matching score is over a predefined threshold. The Process contains following steps.

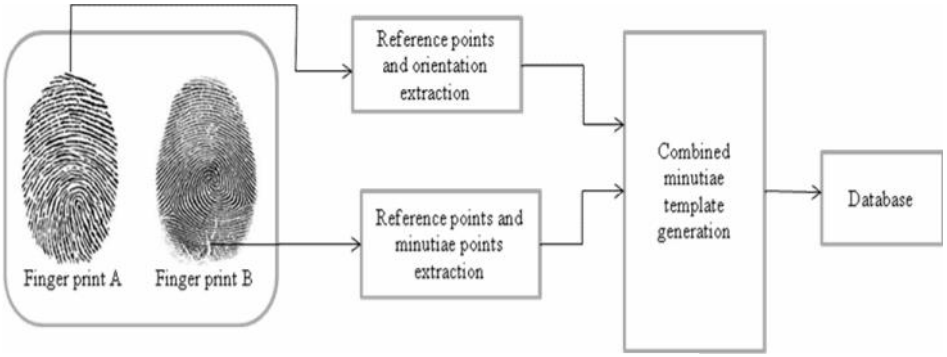

Fig. 1 Proposed System

Fig.2 Fingerprint A

Fig.3 Fingerprint B

Proposed system

In this, we propose hardware-software co-design for protecting fingerprint privacy by combining two different fingerprints into a new identity. During the enrollment, the system captures two fingerprints from two different fingers. Combined minutiae template is generated by extracting minutiae positions from one fingerprint, while the minutiae directions/orientation of the other fingerprint. The template will be stored in a database for the authentication process. A fingerprint matching process is used for matching the two query fingerprints against a combined minutiae template. The combined minutiae template has a similar topology to the original minutiae templates; it can be converted into a real-look alike combined fingerprint by using an existing fingerprint reconstruction approach (Jones 1991). The Proposed System is indicated in the Fig 2. In the enrollment phase, the system captures two fingerprints from two different fingers, say fingerprints A and B respectively. Minutiae positions are extracted from fingerprint A and the orientation from fingerprint B. Then, by using our proposed method, a combined minutiae template is generated based on the minutiae positions, the orientation and the reference points detected from both fingerprints. Finally, the combined minutiae template is stored in a database. In the authentication phase, two query fingerprints are required from the same two fingers, which are used in the process of generating combined

1. Acquisition of Fingerprint Images
2. Preprocessing
3. Reference Point Detection
4. Minutiae extraction
5. Post Processing
6. Identification of Orientation angle

Image Acquisition and Preprocessing

The initial step is to collect the fingerprint images (Thumb & Index Finger) from various individuals using a Digital Persona fingerprint scanner with the resolution of 512dpi. Image acquisition and analysis from the fingerprint sensor determine the pixel width of the structure and the representation of pixel value as well as the image background. Preprocessing consist several processes, such as: image enhancement process, binarization & thinning process.

Image Enhancement

The enhancement may be useful for the following cases

- Connect broken ridges (generally produced by dry Fingerprint or cuts, creases, bruises)
- Eliminate noises between the ridges
- Improving the ridge contrast

The Fourier transformation is widely used in signal and image processing. As the ridges have structure of repeated and parallel lines, it is possible to determine the frequency and the ridge orientation using FFT transform.

- *Divide the image in to processing blocks (b X b) to perform Fourier transforms.*

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\exp\{-j2\pi(\tfrac{ux}{M}+\tfrac{vy}{N})\} \quad (1)$$

For u=0, 1, 2…b and v=0, 1, 2….b. To enhance a specific block multiply FFT of that block by its magnitude. The magnitude of FFT is abs (F (u, v)) = |F (u, v)|.

- *Get the enhanced block by*

$$g(x,y) = F^{-1}\{F(u,v)X\,|F(u,v)|^{k}\} \quad (2)$$

Where F-1 is calculated by

$$f(x,y)=\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}F(u,v)\exp\{j2\pi(\tfrac{ux}{M}+\tfrac{vy}{N})\} \quad (3)$$

For x=0, 1, 2…b and y=0, 1, 2…b. Fix higher k value in equation (2) to improve the appearance of ridges.

Binarization

This process is to convert gray-scale fingerprint image representation in to binary image. Ridges in the fingerprint are highlighted with black color while the background becomes white. Adaptive Binarization method is used to convert gray image to binary image.

Thinning

This process is to obtain one pixel width representation of fingerprint structure. Proposed algorithm is applied on pixel value representation ’0’ adapted to minutiae points’ detection algorithm and avoiding the ROI process. The original algorithm is modified and the process will be based on representation of image with ’1’ for light (white) and ’0’ for dark (black) or region point is for pixel value ’0’ and background point is ’1’. Actually this process is the same with inverting the image and uses the first algorithm to do thinning; of course inverting the image means more computational time.

Reference Point Detection

The proposed multi-resolution reference point detection algorithm is described in this section. The following steps are iteratively applied to the foreground of the segmented fingerprint image starting with w = 16:

i) Estimate the local orientation field B (m.n) using window size 3w x 3w.

ii) For each block pixel θ(m,n), compute (m.n) → (m+l,n) → (m+l.n+l) → (m,n+l) → (m,n+1) → (m,n).

iii) In cases where two core points are detected, discriminate between the concave and convex ridge core points by summing the magnitudes of the local frequency orientation in the 3x3 neighborhood located above each core point; the core point that gives the maximum sum is retained as the reference point. Steps 1-3 are then applied iteratively two more times at finer resolutions w = 8 and 4, but only in the neighborhood of the reference point that was detected.

Minutiae Extraction

The next step after Reference Point detection is the extraction of minutiae. The minutiae points are then extracted by the following method. The binary image is thinned as a result of which a ridge is only one pixel wide. The minutiae points are thus those which have a pixel value of one (ridge ending) as their neighbor or more than two ones (ridge bifurcations) in their neighborhood. This ends the process of extraction of minutiae points. A minutiae point is obtained using

$$CN = 0.5\sum_{i=1}^{8}|Pi - Pi+1| \; with \; P9 = P \quad (4)$$

Crossing number method (CN) on point P, by this formula: If the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending.

False minutiae removal

At this stage false ridge breaks due to insufficient amount of ink & ridge cross connections due to over inking are not totally eliminated. Also some of the earlier methods introduce some spurious minutia points in the image. So to keep the matching system consistent these false minutiae need to be removed. Here first calculate the inter ridge distance D which is the average distance between two neighboring ridges. For this scan each row to calculate the inter ridge distance using the formula:

$$\text{Inter ridge distance} = \frac{\sum Pixels = 1}{rowlength} \quad (5)$$

Finally an averaged value over all rows gives D. Label all thinned ridges in the fingerprint image with a unique ID for further operation using a MATLAB morphological operation BWLABEL.

Following 4 types of false minutia points are removed using these steps.

- If d (bifurcation, termination) < D & the 2 minutia are in the same ridge then remove both of them (case m1)
- If d(bifurcation, bifurcation) < D & the 2 minutia are in the same ridge them remove both of them (case m2, m3)
- If d(termination, termination) ≈ D & the their directions are coincident with a small angle variation & no any other

termination is located between the two terminations then remove both of them (case m4, m5, m6)

- If d (termination, termination) < D & the 2 minutia are in the same ridge then remove both of them (case m7) where d(X, Y) is the distance between 2 minutia points.

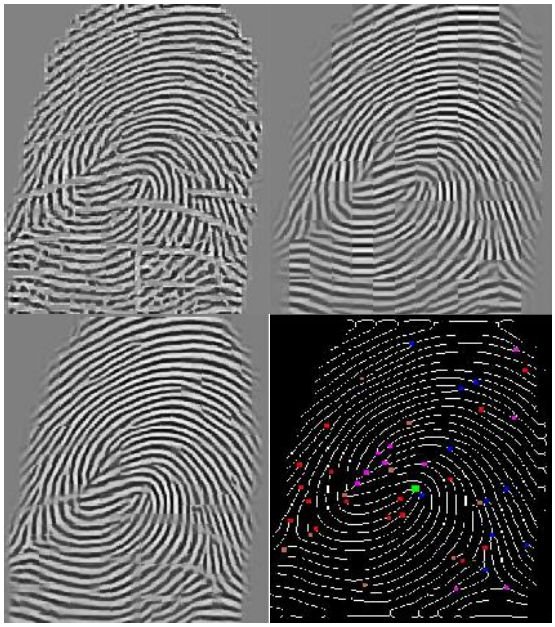

Fig.4 Minutiae extraction from Fingerprint A

Minutiae Direction Assignment

The orientation is an angle formed by the ridge inclination and the horizontal line. As the ridge has no direction, the term orientation is used instead and the angle varies from 0 to 180. Each region of the fingerprint, except the region of singularities, has a common ridge orientation; therefore instead of computing the orientation at each pixel point, generally they are computed for each block. The most simple and very common method used for orientation extraction is based on gradient computation. Initially, the horizontal and vertical gradient are computed at each pixel using for example the sobel operator, then the image are divided in small blocks of size W x W (e.g., size 8x8) and computed the angle by analyzing the block. This method is fast and performs well for good quality images. For low quality images are necessary to used more complex and robust techniques.

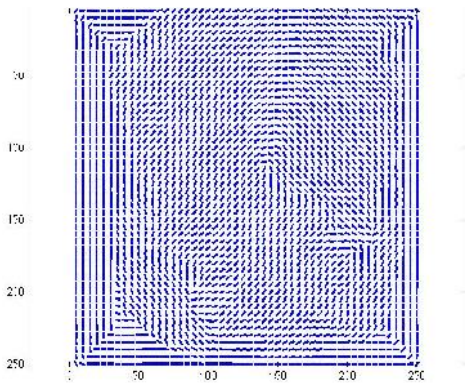

Fig.5 Orientation angle from Fingerprint B

Combined fingerprint

In a combined minutiae template, the minutiae positions and directions are extracted from two different fingerprints separately. These minutiae positions and directions share a similar topology to those from an original fingerprint. Therefore, the combined minutiae template has a similar topology to an original minutiae template. Information needed to reconstruct realistic fingerprints, such as brightness, contrast, the background noise of fingerprint sensor, and detailed ridge features (pores, ridge contours, etc.) is also not available. Thus, a more practical goal is to first estimate the FM representation of the original fingerprint, $\cos\Psi((x,y))$. The 8-bit grayscale fingerprint image is then computed as:

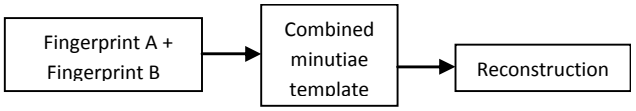

Fig.6 Combined fingerprint generation for two different

To obtain the phase $\Psi(x,y)$., the following four steps are performed:

1. Orientation field reconstruction,
2. Estimation of gradient of continuous phase,
3. Continuous phase reconstruction, and
4. Combination of the spiral phase and the continuous phase.

Reconstruction

1) Estimate an orientation field *O* from the set of minutiae points by adopting the orientation reconstruction algorithm proposed in (23).
2) Generate a binary ridge pattern based on *O* and a predefined fingerprint ridge frequency (which is set as 0.12) using Gabor filtering.
3) Estimate the phase image Ψ of the binary ridge pattern using the fingerprint FM-AM model (14).
4) Reconstruct the continuous phase image Ψ_C by removing the spirals in the phase image.
5) Combine the continuous phase image and the spiral phase image Ψ_S (calculated from the minutiae points), producing a reconstructed phase image Ψ_f.
6) Refine the reconstructed phase image Ψ_f by removing the spurious minutiae points to produce a refined phase image Ψ_{fr}.
7) Apply a noising and rendering step (which is similar to the work proposed in (Reber *et al.*, 1988)) on Ψ_{fr}, so as to create a real-look alike fingerprint image. And this new template is stored in database.

Performance of the proposed system

1) Only one combined minutiae template is used for enrollment. Therefore, there are 25 templates are stored in the database. To compute the False Rejection Rate (FRR), the second impressions of a finger pair are matched against the corresponding enrolled template, producing 25 genuine tests. To compute the False Acceptance Rate (FAR), the

first impressions of a finger pair are matched against the other 49 enrolled templates, producing imposter tests.

2) The first impressions of each finger pair are used to produce two combined minutiae templates for enrollment. Thus, there are 50 templates stored in the database. Similarly, 50 genuine tests are performed to compute FRR and imposter tests are performed to compute FAR.

RESULTS AND DISCUSSION

The performance of the system is evaluated by using a conventional minutiae matching technique (Juette and Zeffanella 1990) for the fingerprint matching. During the authentication, we generate a combined minutiae template from two query fingerprints, which is then matched against the corresponding enrolled template by using a conventional minutiae matching algorithm (Juette and Zeffanella 1990). The experimental results show that our system achieves a very low error rate with EER = 0.4%.

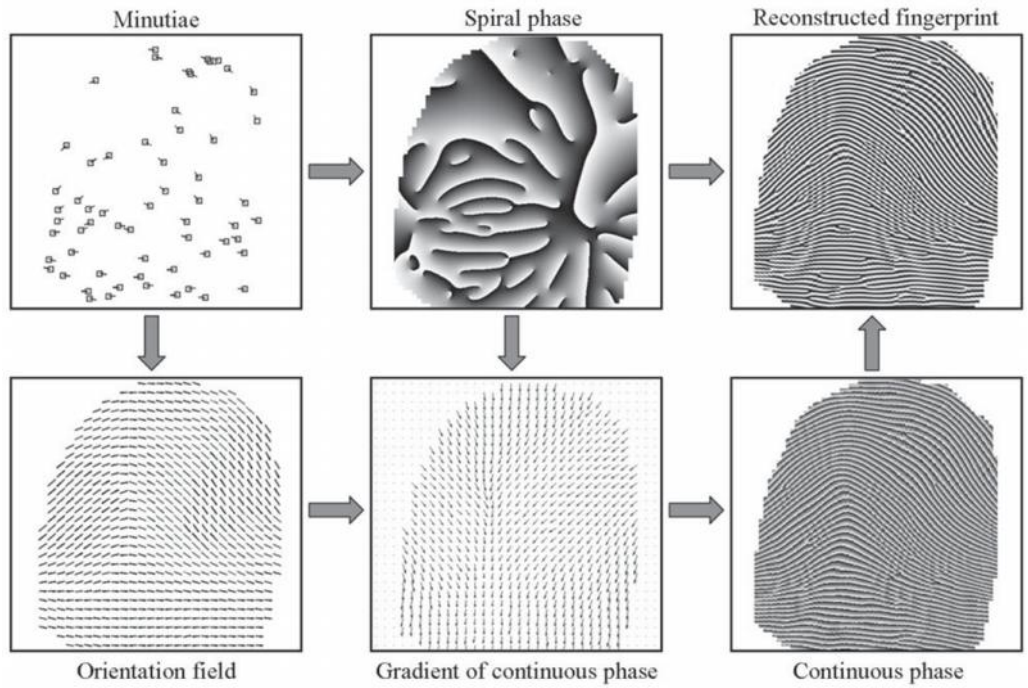

Fig.7 Reconstruction Technique

Fig.8 New template

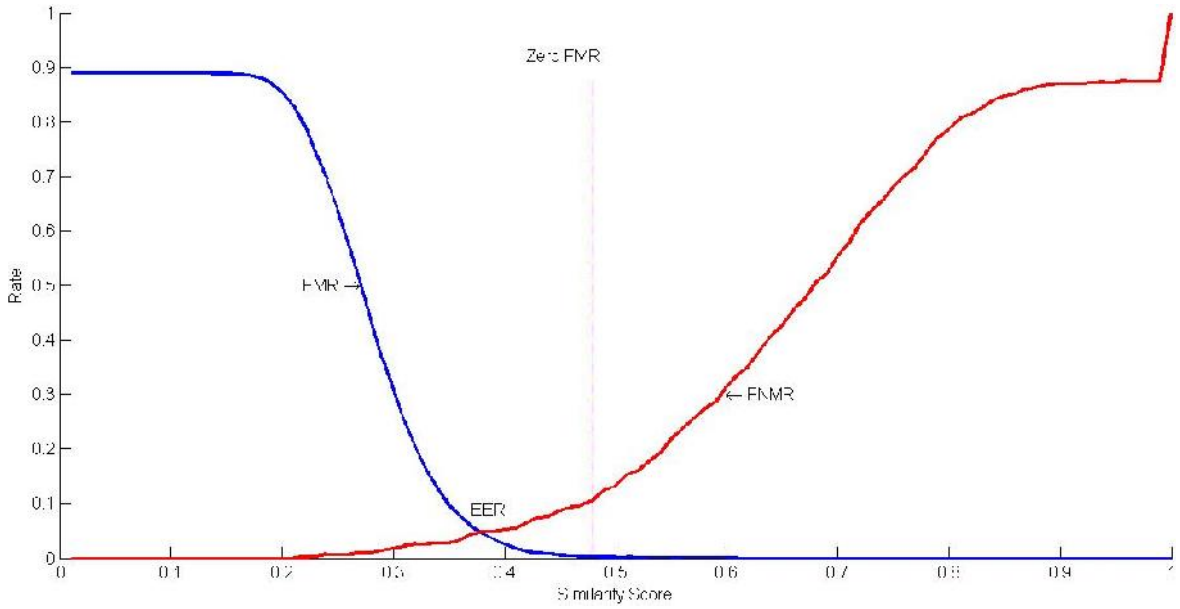

Fig.9 Performance evaluation

Conclusion

In this paper, we introduce a novel system for fingerprint privacy protection by combining two fingerprints into a new identity. In the enrollment, the system captures two fingerprints from two different fingers. A combined minutiae template containing only a partial minutiae feature of each of the two fingerprints will be generated and stored in a database. To make the combined minutiae template look real as an original minutiae template, three different coding strategies are introduced during the combined minutiae template generation process. In the authentication process, two query fingerprints from the same two fingers are required. A two-stage fingerprint matching process is proposed for matching the two query fingerprints against the enrolled template. Our combined minutiae template has a similar topology to an original minutiae template. Therefore, we are able to combine two different fingerprints into a new virtual identity by reconstructing a real-look a like combined fingerprint from the combined minutiae template. It is also difficult for an attacker to break other traditional systems by using the combined minutiae templates. Compared with the state-of-the-art technique, our technique can generate a better new virtual identity (i.e., the combined fingerprint) when the two different fingerprints are randomly chosen. The analysis shows that it is not easy for the attacker to recover the original minutiae templates from a combined minutiae template or a combined fingerprint.

REFERENCES

(Basic Book/Monograph Online Sources) J. K. Author. (year, month, day). Title (edition) (Type of medium). Volume (issue). Available: http://www.(URL)

(Handbook style) *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44–60.

(Journal Online Sources style) K. Author. (year, month). Title. *Journal* (Type of medium). Volume(issue), paging if given. Available: http://www.(URL)

Bingulac S. P., "On the compatibility of adaptive controllers (Published Conference Proceedings style)," in *Proc. 4th Annu. Allerton Conf. Circuits and Systems Theory*, New York, 1994, pp. 8–16.

Chen S., B. Mulgrew, and P. M. Grant, "A clustering technique for digital communications channel equalization using radial basis function networks," *IEEE Trans. Neural Networks*, vol. 4, pp. 570–578, July 1993.

Chen W. K., *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

Doyle W. D., "Magnetization reversal in films with biaxial anisotropy," in *1987 Proc. INTERMAG Conf.*, pp. 2.2-1–2.2-6.

Duncombe J. U., "Infrared navigation—Part I: An assessment of feasibility (Periodical style)," *IEEE Trans. Electron Devices*, vol. ED-11, pp. 34–39, Jan. 1959.

Faulhaber G. R., "Design of service systems with priority reservation," in *Conf. Rec. 1995 IEEE Int. Conf. Communications*, pp. 3–8.

Haskell R. E. and C. T. Case, "Transient signal propagation in lossless isotropic plasmas (Report style)," USAF Cambridge Res. Lab., Cambridge, MA Rep. ARCRL-66-234 (II), 1994, vol. 2.

IEEE Criteria for Class IE Electric Systems (Standards style), IEEE Standard 308, 1969.

Jones J. (1991, May 10). Networks (2nd ed.) (Online). Available: http://www.atm.com

Juette G. W. and L. E. Zeffanella, "Radio noise currents n short sections on bundle conductors (Presented Conference Paper style)," presented at the IEEE Summer power

Meeting, Dallas, TX, June 22–27, 1990, Paper 90 SM 690-0 PWRS.

Kaufman C. J., Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.

Kawasaki N., "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

Kreifeldt J. G., "An analysis of surface-detected EMG as an amplitude-modulated noise," presented at the 1989 Int. Conf. Medicine and Biological Engineering, Chicago, IL.

Letter Symbols for Quantities, ANSI Standard Y10.5-1968.

Lucky R. W., "Automatic equalization for digital communication," *Bell Syst. Tech. J.*, vol. 44, no. 4, pp. 547–588, Apr. 1965.

Miller E. H., "A note on reflector arrays (Periodical style—Accepted for publication)," *IEEE Trans. Antennas Propagat.*, to be published.

Motorola Semiconductor Data Manual, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

Poor H., *An Introduction to Signal Detection and Estimation*. New York: Springer-Verlag, 1985, ch. 4.

Reber, E. E. R. L. Michell, and C. J. Carter, "Oxygen absorption in the Earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (420-46)-3, Nov. 1988.

Smith B., "An approach to graphs of linear forms (Unpublished work style)," unpublished.

Wang J., "Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication)," *IEEE J. Quantum Electron.*, submitted for publication.

Wilkinson J. P., "Nonlinear resonant circuit devices (Patent style)," U.S. Patent 3 624 12, July 16, 1990.

Williams J., "Narrow-band analyzer (Thesis or Dissertation style)," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.

Yorozu Y., M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces (Translation Journals style)," *IEEE Transl. J. Magn.Jpn.*, vol. 2, Aug. 1987, pp. 740–741 (*Dig. 9th Annu. Conf. Magnetics* Japan, 1982, p. 301).

Young G. O., "Synthetic structure of industrial plastics (Book style with paper title and editor)," in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.

Young M., *The Techincal Writers Handbook.* Mill Valley, CA: University Science, 1989.

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