Incorporation of Digital Image Processing into Cybersecurity Curriculum

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Abstract
Cybersecurity curriculum trains the students on different aspects of information security. One of the most important types of information is biometric signature which is usually processed in the form of digital images. Therefore, cybersecurity professionals need to develop expertise in digital image processing. The paper analyzes the role of biometric information in cybersecurity and identifies the skills to successfully design biometric recognition techniques.

Introduction

With the exponential growth of digital and Internet technologies, threats to digital information as well as computer systems are offering critical challenges to professionals and researchers [1]. Hence the demand for cybersecurity professionals is significantly higher than available trained personnel. As a result, the topic of cybersecurity is no longer considered as a branch of computer science and related disciplines, rather it is becoming an independent curriculum. Academic institutions are launching dedicated cybersecurity programs at the bachelor as well as graduate levels.

A crucial component of cybersecurity is biometrics, including face, fingerprint, iris, palm, handwriting [2-3]. Biometric information processing as well as their applications usually involve digital images and videos. Digital image processing itself is a huge topic of academic studies and research, which is typically included in the electrical and computer engineering and computer science curricula [4-5]. Unfortunately, digital image processing topics are not included in a typical cybersecurity curriculum. As a result, the graduates are completely dependent on the image processing tools developed by other engineers or technologists.

The objective of this paper is to analyze the significance of digital image processing techniques in the cybersecurity field. Several security techniques and applications will be investigated to demonstrate the role of digital image processing tools. The goal of the paper is to develop digital image processing topics that are important for the cybersecurity field.

Cybersecurity Curriculum

Cybersecurity curriculum is an applied branch of computer science and information technology fields. Areas of knowledge that are typically covered in such a curriculum include the following.

1. Computer programming,
2. Digital systems,

3. Information security,
4. Cryptography,
5. Network security,
6. Operating systems security,
7. Cloud security,
8. Software security,
9. Vulnerability analysis,
10. Penetration testing/ethical hacking,
11. Risk management,
12. Digital forensics,
13. Cybersecurity law and policy.

Biometrics

Biometrics information is playing a significant role in the field of cybersecurity. Three major areas of biometric information processing in cybersecurity are listed below.

1. Access control: Biometric information is used to verify and authenticate any individual requesting access to confidential information and/or a secure facility.
2. Forensics: Biometric information can be analyzed to identify the person responsible for a malicious activity.
3. Biometric security: Crucial biometric information needs to be protected from any unauthorized access.

Any application of biometrics involves digital image processing tools. Examples of biometrics-based image processing schemes are:

1. Recording and processing of biometric images.
2. Analyzing biometric signatures for identification.
3. Comparing biometric signatures for authentication.
4. Securing biometric signatures through encryption or steganography.

Image Processing Topics

As mentioned earlier, digital image processing consists of a lot of topics which cannot be covered in one or two courses. However, cybersecurity professionals do not need to develop skills in all those topics. Here are some suggested topics that are important for the security field.

Topic	Cybersecurity Learning Outcomes
Continuous- and Discrete-time Signals	• Classify signals based on time characteristics • Analyze digital information in cyber domain
Digital image fundamentals	• Analyze digital images for different security applications • Process digital image for security-related processing
Image enhancement	• Enhance image from poor recording condition

	• Evaluate image histogram and use it for image enhancement
Image bit planes	• Analyze the bit planes of an image for various applications • Utilize the bit planes to hide a confidential information • Encrypt an image using the bit planes
Image Fourier transformation	• Apply Fourier transformation on image to analyze its frequency-domain characteristics • Develop an image encryption algorithm in frequency domain
Image filter	• Design filter for processing an image for various applications • Detect edges for biometric authentication purpose
Image noise	• Investigate noise in an image • Restore a clean image by reducing noise
Image pattern classification	• Classify objects in a given image • Detect and recognize a target for forensic/security applications
Digital video basics	• Analyze video signals • Design security technique for live biometric authentication
Security applications	• Take some real-world scenarios and apply the image processing knowledge for cybersecurity applications

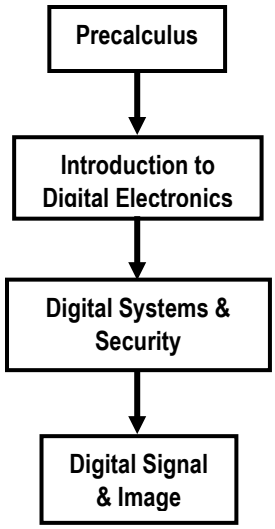
Sequence of Courses

The digital image processing skills require background knowledge in digital electronics, calculus, and computer programming. The students need to learn how digital information is processed in hardware and understand the logic algebra. The knowledge will be crucial in recording biometric and other images from the real world to digital domain and processing them for cybersecurity applications. Image processing techniques involve some detailed mathematical analyses where linear algebra and calculus are essential components. Mathematical image processing models need to be implemented using a computer program. Though MATLAB is the most popular programming tool for image processing applications, other programming languages, like Python, C++, are also suitable. Finally, the image processing algorithm is transferred to a hardware utilizing some microcontroller integrated circuits, including FPGA.

Case Study

Farmingdale State College has launched a unique bachelor degree program in Computer Security Technology. It includes a course on digital image processing which has the course sequence shown in Fig. 1. The curriculum prepares the students through a couple of basic courses on

mathematics, digital electronics, and information security. The student who successfully



completes the course are well-equipped to handle biometric recognition challenges.

Fig. 1: Course sequence for the image processing course

Conclusion

Digital images are crucial components of cybersecurity. Therefore, any cybersecurity education and research should include digital image processing techniques. Several components of digital image processing tools are demonstrated in this paper with relevance to forensic and security analyses and applications. Graduates with skills in digital image processing are better trained and equipped to design, develop, and manage biometric-based cybersecurity systems.

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