Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org

Volume 25, Issues 5, pp. 4390–4398, DOI 10.12694/scpe.v25i5.3179

SPORTS DATA PRIVACY PROTECTION AND INFORMATION SECURITY MANAGEMENT

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Abstract. In order to achieve the protection of personal privacy, the author proposes research on sports data privacy protection and information security management. The author used the two-dimensional fractional Fourier transform (2D-FRFT) method to encrypt the detected human body parts, which can be decrypted when needed for viewing. Compared to traditional Fourier transform, Fractional Fourier Transform (FRFT) can better express the time-frequency characteristics of signals and is very sensitive to the order of the transform. It is widely used in image encryption systems. 2D-FRFT increases the range of keys, further enhancing the security of the system. The author achieved encryption by extracting the detected human body parts and then performing a certain order of FRFT in the x and y directions respectively; When decrypting, use the same order of encryption to perform inverse fractional Fourier transform. Finally, based on research on pedestrian detection and encryption technology, the author designed a human-machine interaction interface that integrates the functions of detection and encryption interfaces, making the entire operation more intuitive and concise.

Key words: Pedestrian detection, Fractional Fourier transform, Interactive interface, Information Security Management

1. Introduction. Human body detection refers to the use of computers to detect human targets in image files, which has been studied and developed for many years. However, it is affected by factors such as shooting angle, human posture, background and lighting intensity, occlusion, and pedestrian gathering, its detection algorithm still needs continuous improvement [1]. At present, human body detection technology has been widely applied in intelligent video surveillance, robotics, virtual reality, and safe driving of vehicles. With the rapid development of society, more and more unstable factors have emerged. For safety reasons, intelligent video surveillance has been successfully applied in many public places, such as security checks, highways, elevators, banks, shopping malls, etc. When the system detects abnormal emergencies, it can understand, analyze and judge the behavior of the detection target, timely alarm and respond to corresponding measures, in order to ensure the safety of people's lives and property, and then minimize losses. Intelligent robot technology has been widely applied in various industries in society. Currently, intelligent robots are mainly used to complete high difficulty and high-risk actions that are not easy to manually complete. For example, in the event of an earthquake disaster, intelligent robots can be used to participate in search and rescue work, which to some extent improves search and rescue efficiency [2-3]. And the positioning of these disaster victims can be achieved through human detection technology. With the increasing number of private cars year by year, the time and space distance between people has been shortened, but the negative impact cannot be ignored. For example, traffic safety accidents that may occur at any time can threaten people's life and property safety. Therefore, research on safe driving of automobiles is particularly important. If a camera is installed on the vehicle that can collect information in front of the vehicle's line of sight, it can detect and recognize whether there are pedestrians in front, whether they are within a safe range, understand and analyze pedestrian behavior, predict the possibility of collision, and provide relevant information to the driver in a timely manner, so that the driver can make timely and correct responses and prevent frequent traffic accidents. Virtual reality is a high-tech that has developed in recent years. Its main principle is to use computer technology to construct a three-dimensional simulation space, providing users with simulations of visual, auditory, and tactile senses, giving them a sense of firsthand experience. There is enormous potential research value in medical surgery, entertainment games, military aerospace, and other fields. Among them, relevant positioning requires pedestrian detection technology to support. Human beings have always been in a dominant position in social activities, and they are also a

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key object of object detection. With the development of human detection technology, it has provided practical convenience for many fields and has broad development and application prospects.

Human detection is a research topic with strong practical application value. Many scholars at home and abroad have conducted in-depth research and achieved certain research results [4-5]. Since 1997, the US Defense Advanced Research Projects Agency has funded a major research project on visual surveillance technology and video understanding, with the participation of many universities. The European Union has also increased funding for pedestrian detection related technology research since 2000. Compared to foreign research in this field, China's development research is later. However, in recent years, the discovery of potential application value has attracted the attention of many domestic universities and scientific research institutions, and in-depth research has been carried out in this field. The State Key Laboratory of Pattern Recognition of the Chinese Academy of Sciences has made many outstanding achievements in this field. The effectiveness of pedestrian detection has a significant impact on the stability of video surveillance systems. So far, there are many methods for pedestrian detection, but there is no universal algorithm, and each method has its own characteristics. These methods mainly include frame difference method, background difference method, template matching method, optical flow method, and machine learning based detection method. The frame difference method mainly determines whether a pixel belongs to a foreground point by subtracting the corresponding grayscale values of the two frames in the video sequence, in order to determine the motion target that appears in the video sequence. But this method is limited to only pedestrians in the moving target. The background subtraction method is to subtract the current image frame from a known background model, in order to determine whether the pixels in the current image frame are foreground points. This algorithm has a simple principle and good real-time performance, but if there is no movement of pedestrians in the image, the detection will fail.

The template matching method requires prior knowledge of the characteristics of the detected object, such as contours, edges, etc. The principle is to compare these feature templates with the video image frames to be detected. If the template's features are met, it can be determined as the detection target. However, due to the fact that humans are non rigid bodies and have different postures, the actions presented at different times are not uniform, making it impossible to form an accurate and effective template, resulting in low accuracy in pedestrian detection. The optical flow method can detect independent moving targets without prior knowledge of any background prior. However, the optical flow method requires high hardware requirements for the equipment and has certain limitations in areas with high real-time requirements. Machine learning based methods can overcome many unfavorable conditions and have good stability. Due to the differences in height, posture, movement, clothing, skin color, lighting conditions, and background, pedestrian detection poses great difficulties. It is difficult to find a unified detection algorithm that meets real-time requirements and has a high recognition rate. In order to overcome these difficulties, pedestrian detection methods based on statistical learning are often used more frequently. This method mainly consists of three steps. Firstly, it extracts the features of pedestrians. Currently, the commonly used features include grayscale directional histogram features, hall features, and edge contour features, each with its own characteristics and suitable application scenarios; Then, the classifier is selected to train the extracted features and obtain file data that can be used for final classification; Finally, send the image to be detected to the classifier for detection. Many domestic scholars have conducted extensive research on statistical learning based pedestrian detection methods, which have the advantage of adapting to the variability of non rigid detection objects, and the accuracy of detected pedestrian targets is high and relatively stable. The disadvantage is that a large number of training samples are required. Sometimes, due to the high dimensionality of sample features, it takes a long time to train the classifier and use it for detection, and the real-time performance is not ideal.

With the deepening of research, the technology of pedestrian detection has achieved many achievements so far, but it still lacks a wider application and more stable performance. This is mainly due to the particularity of the pedestrian object, and its main difficulties are as follows: pedestrians are located with different backgrounds, which will also have a greater impact on the detection results.Some images have a single background, such as in the grassland, desert, open vision, etc., relatively pedestrians are relatively easy to detect. Some images have a complex background, such as in shopping malls, squares, tourist attractions and crowded roads and streets, the flow of people gathers, so there will inevitably be pedestrian blocking phenomenon, so that only a part of the human body can be seen in the image, so that enough information can not be obtained from the

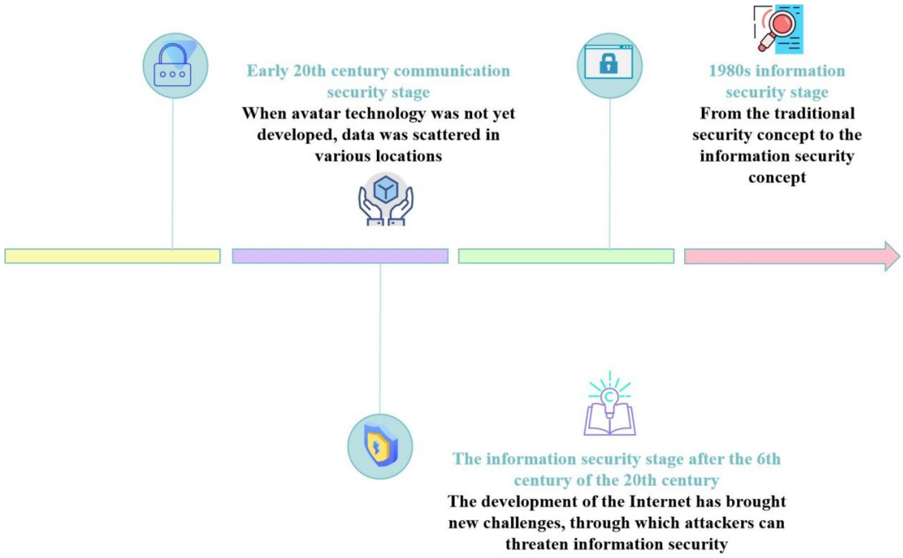

Fig. 1.1: Information Security Management and Privacy Protection Diagram

image, which affects the detector for analysis and judgment.At the same time, in some special backgrounds, some backgrounds are similar to the human body, such as tree trunk, telephone poles, etc., these disturbing background objects can easily be mistaken for the human body by the detector, thus reducing the detection accuracy. Camera can from the front, side, the back of the pedestrian, the results have the very big difference, and the influence of the distance between the camera and people, showing the pedestrian size is very different, and body parts also have difference, and in large traffic, sometimes in order to make the view more broad, need to improve the height of the camera, lead to the clarity of the photo is not quite the same. Because people are not rigid body, to a certain extent, both a certain rigidity, and a certain flexibility.Lead to the human body can show a rich change of posture, such as: upright, squatting, etc., even if the same person shows different movements, the test results-like also has a relatively large impact. At the same time, there are also differences in height, weight, clothing, etc., these characteristics will also bring some difficulties to detection. Even in the same place and under the same background, due to the different moments of photo collection, there can also be some differences in the light intensity. Some photos are brighter and some are darker. The differences in these rays will directly lead to the different image information extracted, which will ultimately affect the classification results.Therefore, the effect of reducing light intensity is also an aspect worth studying. Commonly used to describe the characteristics of the human body have edge, contour, texture features, gradient direction histogram features and the features back, these features can be used for pedestrian detection, but the results of different characteristics are often different, some feature detection results in addition to the algorithm used, will also be affected by the detection of image properties.So choosing a suitable feature is very important for the accuracy of the detection. In practical application, the system is often required to have good real-time, can quickly detect the human body part, and the corresponding understanding and analysis. However, the calculation amount of the algorithm directly restricts the real-time performance of the system, so the accuracy of detection is not affected as much as possible. It is very necessary to select a suitable algorithm above.

The author designed a concise human-computer interaction interface, which mainly includes image reading, detection of pedestrian parts, extraction of detected human parts, and encryption and decryption. The interface integrates all steps, making the operation of the entire privacy protection system more concise, intuitive, and user-friendly. Finally, the time complexity of all process modules in the system, including pedestrian detection, encryption, and decryption, was analyzed. Figure 1.1 shows information security management and privacy protection [6].

2. Methods. With the rapid development of computer and internet technology, network-based information exchange platforms have provided great convenience for the dissemination of digital works. However, the protection of property rights of digital works is also an issue that cannot be ignored [7]. Due to the intuitive and informative nature of image information, as well as the confidentiality requirements in certain specific fields, encryption and protection technologies for the growing demand for image information transmission are receiving increasing attention.

2.1. Introduction to the Development of FRFT. The reason why FRFT can be quickly and widely applied in the field of optics is because it is relatively easy to achieve this transformation based on optical devices [8,9]. Although FRFT has strong practical value in signal processing, this transformation lacks effective physical explanations and has low algorithm efficiency, resulting in it not receiving enough attention in signal processing. Nowadays, with the continuous in-depth research and development of FRFT, a large number of related research results have emerged.

2.2. Main Applications of FRFT. The unique properties of FPRFT have attracted the attention of many learners and researchers. Nowadays, PRFT has been widely applied in many fields of scientific theory research and engineering application technology, such as wavelet transform, quantum mechanics, optical signal processing, artificial neural networks, video analysis, etc. The following mainly introduces some typical applications of FRFT in different fields.

(1) Chirp class signal detection and parameter estimation. The traditional Fourier transform is a transformation within the overall range that obtains the entire spectrum of a signal [10]. And FRFT can be seen as the decomposition of signals on orthogonal chirp basis, so FRFT is particularly suitable for the analysis and processing of chirp signals. In the detection of moving targets by radar, most of the received echo signals are chirp signals. The convenient processing of chirp signals by FRFT greatly improves the performance of signal processing systems in detecting moving targets and estimating their parameters.

(2) Filtering. The FRFT of a signal refers to the rotation of the signal at a certain angle in the time-frequency plane, which is very beneficial for the processing of non-stationary signals [11]. Traditional filtering methods mainly perform windowing operations in the frequency domain, but when the time-frequency coupling between the signal and noise is strong, it is difficult for traditional filtering methods to completely separate them. At this point, if the signal is rotated at a specific angle in the time-frequency plane, causing the signal and noise to lose coupling in the new Fourier domain, they can be separated well.

(3) Neural networks. Compared to traditional Fourier transform, FRFT has an additional transformation order p and can be freely selected from 0 to 1, making the transformation more flexible. In this case, if the neural network is in this domain, it can have a more stable effect [12].

(4) Digital watermark. The so-called digital watermark refers to embedding relevant marks in certain digital works in a specific way to verify copyright ownership. At the same time, this information should be ensured to be invisible and not perceived by anyone, and can only be detected by the copyright owner through special technical means. Digital watermarking technology is mainly aimed at protecting digital media. When property disputes arise, relevant information in the watermark can be extracted to verify copyright ownership. Due to the sensitivity of FRFT to the order of transformations, watermarking techniques based on FRFT correspond to different transformations at different orders. By adding key parameters, the security of the watermarking system is improved without knowing the order of transformations.

2.3. Definition of FRFT. The traditional Fourier transform is well-known to everyone, and its theoretical research and development are relatively mature, and it has been well applied [13]. And FRFT is based on the theoretical foundation of traditional Fourier transform, which is a refinement and supplement to it. The traditional Fourier transform can be regarded as a linear operator that rotates the angle /2 counterclockwise from the time axis to the frequency axis, while FRFT can be regarded as an operator that rotates any angle a. Compared to traditional Fourier transform, FRFT has greater advantages in application. It not only possesses some properties of traditional Fourier transform, but also adds some new characteristics related to its own properties. There are various definitions of FRFT based on different perspectives, but each definition has a certain inherent connection. Defining FRFT from different perspectives can help us have a more comprehensive understanding of it.

2.4. FRFT Properties and Characteristics.

(1) The properties of FRFT. FT represents the differential operator acting on the function, and F^P is the p-th power of FT, which means that if the function is rotated by an angle p, the p-th order FRFT can be understood as treating FP as an operator to generate FRFT [14]. The main properties of FRFT are as follows:

Interchangeability: Perform FRFT on a function with order P1 first, after performing FRFT with order p2, the result is the same as performing FRFT with order P2 first and then FRFT with order p1, that is: $F^{P1}F^{P2} = F^{P2}F^{P1}$.

Order additivity: For different p1 and p2, there is always $F^{P1}F^{P2} = F^{P1}F^{P2}$.

Linear transformation: Satisfies the superposition principle, that is $F^P|\sum c_n f_n(u)| = \sum c_n|F^p f_n(u)|$.

Periodicity: According to a=pr/2, the period of order p is 4, which is $F^{p+4} = F^p$.

Reversibility: After performing p-order FRFT on a function, followed by-p order FRFT, the original function can be obtained. There are: $(F^p)^{-1} = F^{-p}$[15].

(2) The main characteristics of FRFT. From the definition form of FRFT, it can be seen that FRFT reflects a time-frequency information of the signal, which is an extension of traditional Fourier transform and particularly suitable for processing non-stationary signals. Moreover, it has an additional transformation order p, making the transformation angle more flexible. Moreover, the discrete algorithm of FRFT has high efficiency and fast speed. Compared to traditional Fourier transform, FRFT mainly has the following characteristics:

The transformation order of FRFT can continuously increase from 0 to 1, demonstrating the continuous time-frequency variation characteristics of the signal, providing a better platform for time-frequency analysis of the signal [16].

FRFT can be seen as a decomposition of chirp groups. In radar signal processing, most of the echo signals for detecting moving targets are chirp signals, which is beneficial for improving the performance of signal processing systems in detecting moving targets and estimating their parameters.

FRFT has an additional transformation order p compared to traditional Fourier transform, which increases the value space of the key and improves the security performance of the system in image watermarking and encryption systems.

FRFT is a linear transformation without cross interference, which has advantages in the presence of additive noise.

FRFT is easy to achieve through optical transposition and has a wide range of applications in the field of optics.

The development of FRFT is relatively mature, with fast and efficient discrete algorithms, and it provides fast discrete algorithms for fractional convolution and other applications. At the same time, it also makes it easier to promote in practical applications.

2.5. 2D-FRFT. Perform one FRFT on f (x, y) in the x and y directions respectively to obtain 2D-FRFT. 2D-FRFT is implemented based on FRFT, and its kernel function can be expressed as:

$$K_{p1,p2}(x,y,u,v) = \frac{\sqrt{1-jcot\alpha}\sqrt{1-jcot\beta}}{2\pi} \times exp \\ [(\frac{x^2+u^2}{2tan\alpha} - \frac{xu}{sin\alpha})j]exp[(\frac{y^2+v^2}{2tan\beta} - \frac{yu}{sin\beta})j] \tag{2.1}$$

In the above equation, α=p1n/2, β= P2 /2 represents the two rotation angles of 2D-FRFT, respectively. If the corresponding transformation orders p1 and p2 are given, 2D-FRFT can be represented in the following form:

$$F^{p1p2}(u,v) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} K_{p_1p_2}(x,y,u,v)f(x,y)dxdy \tag{2.2}$$

Similar to FRFT, the inverse transformation of 2D-FRFT only requires taking the opposite order of the corresponding order. As shown in the following equation:

$$f(x,y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} K_{-p_1-p_2}(x,y,u,v)F^{p_1p_2}(u,v)dudv \tag{2.3}$$

From equation 2.1, it can be seen that the transformation kernel of 2D-FRFT can be separated, which is:

$$K_{p_1,p_2}(x,y,u,v) = K_{p_1}(x,u) \times K_{p_2}(y,v) \tag{2.4}$$

The two-dimensional discrete FRFT can be seen as the result of two one-dimensional discrete FRFTs. The transformation process is as follows:

1. Firstly, perform discrete FRFT on the two-dimensional discrete signal in the x-direction to obtain F1;
2. Then perform discrete FRFT on the two-dimensional discrete signal in the y-direction to obtain F2;
3. Finally, by transposing F2, a two-dimensional discrete FRFT can be obtained.

When $\alpha = \beta$ When, it is symmetric 2D-FRFT; If $\alpha = \beta = \ /2$ is the traditional 2D-FRFT; When $\alpha \neq \beta$ When, it is an asymmetric FRFT [17].

3. Results and Analysis. The author designed and implemented a demonstration system that can integrate human body detection and privacy protection functions. This system can perform human body detection on input images and extract the detection part for encryption and decryption. The input image can be a real-time image captured by the camera or a pre saved image in the hardware device.

3.1. Introduction to System Interface Function Modules. As a demonstration system, it is required to be able to interact with users. Based on basic functional requirements, the interface of this demonstration system includes four parts: input area, functional area, display area, and operation instruction area. Input area: By inputting in the x and y directions, the detected pedestrian part can be encrypted and decrypted with any order of fractional Fourier transform. Functional area: Mainly realizes the input of images (supports real-time shooting or opening of saved images from the camera), detects pedestrians in the images, encrypts and decrypts the detected pedestrian parts, and has the function of exiting the system. The included function buttons include: Turn on the camera, turn off the camera, take and save photos, open pictures, save pictures, pedestrian detection, encryption, decryption, and exit. Display area: Mainly displays the input image, as well as the results of pedestrian detection, encryption, and decryption of the input image. Operation Instruction Area: This area mainly provides an operation instruction for the entire demonstration system and provides a brief summary of the system principles.

3.2. Demonstration System Design Principles. This interface is designed based on the GUI (Graphical User Interface) module of MATLAB. Human body detection is implemented on the open-source platform OpenCV. MATLAB is currently one of the most widely used mathematical software, but due to its use of line interpretation to execute code, it to some extent limits the execution speed of the code. The open-source code of the OpenCV class library is written in C and C++, and the code execution efficiency is high [18]. Combining the advantages of these two languages and leveraging their respective strengths often yields better results. When calling a cpp file in MATLAB, it is necessary to first convert the cpp file into a mex file in a certain format. The mex file is developed in C/C++language, after being compiled in a certain way, it can be called by the m language interpreter in MATLAB.

Compared to interface software packages such as MFC, the GUI functions in MATLAB are simple, and the message mapping mechanism is concise, making it particularly suitable for system interface design that is not particularly demanding. MATLAB integrates an efficient interface development environment called Guide, which includes various MATLAB supported control objects, and users can choose different interface appearances and set different action response methods for controls. A complete GUI creation, firstly, it involves the selection of controls and spatial layout in interface design. Then, in order to respond to certain operations, it is necessary to write callback functions. Through callback functions, the specified functions of the controls can be achieved.

Table 3.1: Human detection time

Image size (pixels)	648∗384	463∗636	301∗488	364∗556
mean time to detect (ms)	2139.42	2865.59	1629.19	1927.04

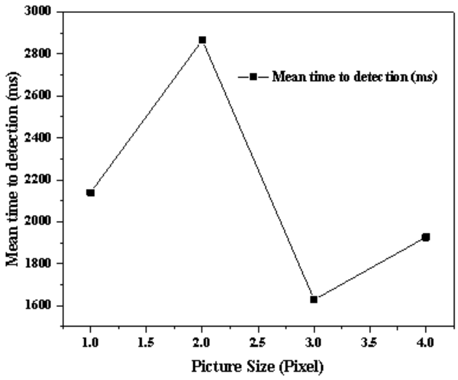

Fig. 3.1: Human detection time chart

Table 3.2: Detected encryption time of human body parts

Image size (pixels)	191∗383	210∗420	142∗283	116∗232
mean time to detect (ms)	834.15	1211.41	311.49	195.65

3.3. Experimental section. Firstly, load the saved image from the hardware device using the "Open Image" button, and use the "Pedestrian Detection" button to detect the human body part of the input image. After detecting pedestrians, the system extracts the human body part. Then, by setting the order in the x and y directions, the corresponding order of encryption can be achieved for the human body part.

A time complexity analysis was conducted on the human body detection, encryption, and decryption parts of the entire system, as shown in Tables 3.1, 3.2, and 3.3. The computer system used in the experiment was Windows 7 flagship version, and the software versions used were vs2010 flagship version, OpenCV2.44, and MATLAB 2013a. The main hardware environment of the computer is: Intel Pentium dual core T4300@2.10CHz Processor, memory 3.00GB [19].

The following table lists the image size and corresponding operation time. From Table 3.1 and Figure 3.1, it can be seen that the detection speed is related to the image size, and the larger the image, the longer the required time [20]. Detecting a $648 * 384$ image requires 2139.41 milliseconds, which takes a long time and has low real-time performance, this is because the selected HOG features have a dimensionality of 3781 and require complex computation. In order to ensure both detection rate and real-time performance, this is a major challenge that needs to be overcome in the current field of pedestrian detection. Tables 3.2, 3.3, Figure 3.2, and 3.3 respectively encrypt and decrypt the pedestrian parts detected in the images in Table 3.1. It can be seen from the tables that real-time performance is still a challenge that cannot be ignored. So, there are still many areas that need to be improved and enhanced for pedestrian detection and encryption in real-time videos.

4. Conclusion. The author mainly implemented it based on 2D-FRFT, not only analyzing the principle of FRFT for image encryption, but also providing the encryption and decryption effects of different orders in the x and y directions through experiments, as well as the slight deviation of the decryption order relative to the encryption order, which affects the decryption effect of the image. Enable readers to fully understand

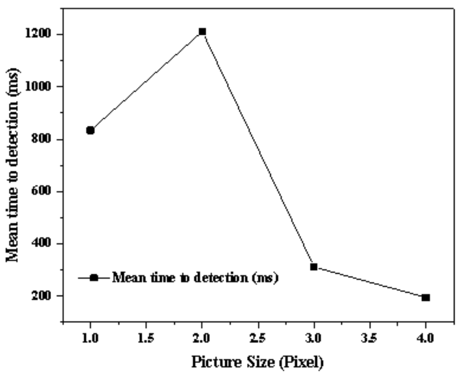

Fig. 3.2: Encrypted time graph of detected human body parts

Table 3.3: Decryption time for encrypted parts

Image size (pixels)	191∗383	210∗420	142∗283	116∗232
mean time to detect (ms)	831.56	1017.9	374.82	200.20

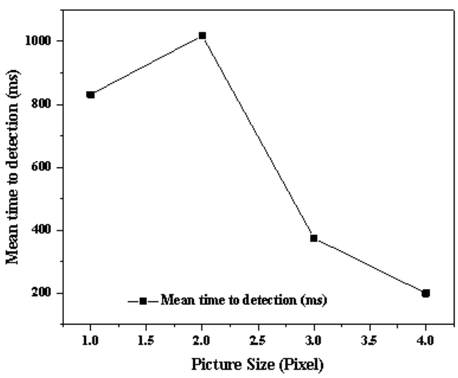

Fig. 3.3: Decryption time graph for the encrypted part

that different orders of FRFT have significant differences in image encryption and decryption effects. In the system design section, the author utilized the GraphicalUserInterface module in MATLAB, fully considering functional requirements and interface aesthetics, in order to design an interface that can take real-time photos and save, as well as both pedestrian detection and encryption and decryption of pedestrian parts. It has the characteristics of simple operation, complete functions, and beautiful interface.

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Edited by: Hailong Li
Special issue on: Deep Learning in Healthcare
Received: Jan 14, 2024
Accepted: Feb 22, 2024