Active image quality reconstruction technology based on flexible display

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Abstract: The method of active image quality reconstruction adaptive camouflage based on flexible display technology is to use flexible display devices to combine spectrum transfer technology and active image quality reconstruction technology to achieve the change, transfer and selective distribution of the target surface spectral radiation characteristics. In this design, the optical characteristics of the target could be changed by modulating the optical characteristic parameters of the target surface, and the background image could be captured in real time during the activity of the target and displayed on the flexible display. The use of active image quality reconstruction, flexible display and emissivity control layer achieves the purpose of modulating the infrared radiation intensity of the target and effectively segmenting the target heat map, so as to achieve a high degree of integration with the surrounding natural environment throughout the weather and the whole process, and the spectrum of the target surface. The distribution characteristics do not change with the change of the detection direction, achieve the effect of target camouflage. Compared with the method of changing the physical structure characteristics of the target surface, this technique makes the target environment more adaptable and more survivability, and easy to implement.

Key words: camouflage; flexible display; image quality reconstruction; adaptive

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基于柔性显示的主动像质重构应用技术

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摘 要：基于柔性显示技术的主动像质重构自适应伪装方法是利用柔性显示器件结合频谱转移技术和主动像质重构技术实现目标表面光谱辐射特性的改变、转移和选择性分布。文中设计通过调制目标表面的光学特性参数改变目标的光学特征，可以实现目标在活动过程中实时拍摄背景图像，将其显示于柔性显示器上。利用主动像质重构、柔性显示和发射率控制层达到调制目标的红外辐射强度和有效分割目标热图的目的，从而实现全天候、全过程与周围的自然环境高度融合，并且，目标表面的光谱分布特征不随探测方向的变化而改变，达到目标伪装的效果，相较于改变目标表面的物理结构特征的方法，这样的技术使得目标的环境适应性更好，且易于实现。

关键词：伪装； 柔性显示； 像质重构； 自适应

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0 Introduction

The spectral radiation characteristics of the target surface are affected by the emissivity, reflectivity and transmittance of the target surface material. By modulating these optical characteristics of the target surface, the selective distribution of the target surface spectral radiation can be achieved[1−2]. The spectral selection surface uses the effect of spectral filtering to selectively reflect or transmit electromagnetic waves and light waves. It is precisely because of the electromagnetic filtering function of the open space presented by the spectral selection surface that it has a greater application value in the fields of science and engineering, and has received more and more attention from countries all over the world in recent years[3−5].

Based on flexible display technology, this paper studies the method of active image quality reconstruction and self-adaptive camouflage. This technology uses flexible display devices combined with spectrum transfer technology and active image quality reconstruction technology to achieve the change[6], transfer and selective distribution of the spectral radiation characteristics of the target surface. The spectral distribution characteristics of the target surface do not change with the detection direction.

1 Main study objectives

During the movement of the target, the background will undergo more complex changes. However, traditional camouflage equipment only has a fixed optical characteristic signal, which is only suitable for use in specific and simple situations to match background characteristics. The movement of the target or the change of the target's environment makes the target's exposure signs obvious, reducing the combat capability and survival probability.

The spectral selection surface can achieve multiple purposes such as low-pass, high-pass, band-pass, and two-color filtering. This feature can be widely used in stealth and anti-stealth design of combat targets, different from millimeter wave and sub-millimeter wave spectrum selection surface research, design, preparation and experimental measurement mechanism. Because the wavelength of the spectral band is shorter, for a long period of time, the study of spectral selection surfaces is restricted by the manufacturing process and the selection of available materials. However, with the development of micro-fabrication technology, especially the advancement of the industrial application of photonic printing technology, the preparation of spectrally selective surfaces has become possible and shows great application potential.

An typically a multi-layer system comprising an active element sandwich between two electrodes[7−13]. The active element comprises optically and electrochemically active layers. Between the active layers is an electrolyte layer. The ions in the active element move through the electrolyte from one active layer to the other by application of small voltages to the electrodes. The ion intercalation/extraction from the electrochemically and optically active layers changes the optical properties of the overall system. Electrochromic devices were investigated as a means of efficiently modulating the IR emissivity of target 's structures. The optical properties of electrochromic materials are modified upon application of a voltage allowing a high degree of control of the modulation[7]. Just as shown in Figure 1.

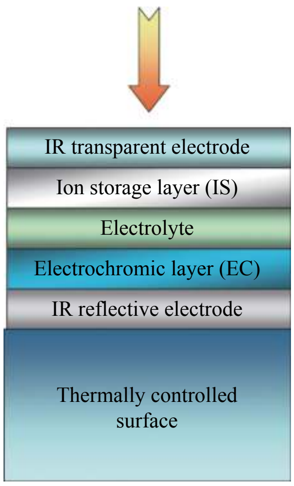

Fig.1 Cross section illustration of an eclipse IR-ECDTM with a metamaterial IR transparent electrode

It is exhibits two alternative modes: (1) transparent, non-absorbing low-e mode; and (2) highly absorbing, low reflectance high-e mode.

Using flexible obstructing equipment to shoot the background in real time during the target activity, and the background image on the obstructing equipment is displayed through image quality reconstruction, flexible display and emissivity control layer. It achieves the purpose of suppressing the infrared emission intensity of the target and effectively segmenting the target heat map, so as to achieve a high degree of integration with the surrounding natural environment in the whole weather and the whole process, and an ideal camouflage effect on the dynamic and static conditions of the target, facilities and equipment is obtained.

2 Active image quality reconstruction technology

The technology of applying the basic principles of graphics and image processing methods to adaptive camouflage has been widely used. Active image quality reconstruction adaptive camouflage technology is the use of image processing methods to reconstruct image quality through modulation functions such as stretching and distortion in the displayed image, matching the flexible display technology, and designing the surface material characteristics of the display device parameters, realize the change of the target's optical characteristics, and achieve the effect of camouflaging the target.

Using the constraint method to solve the image reconstruction problem, the objective function of image modulation can be characterized as[7]:

$$\phi(x)=\frac{1}{2}\left\|y-\overrightarrow{H}x\right\|+\lambda\varphi(x) \tag{1}$$

Where, y is the degradation result of the ideal image x, $\overrightarrow{H}$ is represent linear degradation, $\varphi(x)$ is a priori constraint imposed on the image, and λ is the regularization parameter is used to adjust the proportion of the target function before and after. For the original image x, it can be characterized by the coefficients θ in the transform domain:

$$x=\overrightarrow{A}\theta \tag{2}$$

The image modulation problem is transformed as follows:

$$\tilde{\theta}=\arg\min_{\theta}\frac{1}{2}\left\|y-\overrightarrow{H}\overrightarrow{A}\theta\right\|^2+\lambda\varphi(\overrightarrow{A}\theta) \tag{3}$$

There is,

$$\tilde{x}=\overrightarrow{A}\tilde{\theta}$$

And $\varphi(x)$ is equivalent to $TV(x)$

$$\varphi(x)=TV(x)=\sum_{(i,j)\subset x}\sqrt{\overrightarrow{D}_h(i,j)^2+\overrightarrow{D}_v(i,j)^2} \tag{4}$$

There, the horizontal gradient operator $h_x=[01-1]^{\mathrm{T}}$, the vertical gradient operator $h_y=[10-1]^{\mathrm{T}}$.

In recent years, flexible display technology has made great progress and development under the background of huge demand. Combined with the performance characteristics of flexible displays, the research and preparation of display devices with different performances are also changing with each passing day. In addition, materials that can achieve changes in spectral characteristics have been successfully developed and can be used for reference in related fields.

3 Active image quality reconstruction based on flexible display

With the development of display technology, it has experienced cathode ray display(CRT), liquid crystal display(LCD), plasma display(PDP), inorganic semi-conductor light-emitting diode(LED) display and organic LED(OLED) display. With the rapid development of science and technology, display technology is also changing with each passing day. The old technology is constantly improved, and new technology is proposed and implemented. Although the thickness of OLED panel is several millimeters, other flat panel display technologies are hard to match, but the development of OLED will not stop, and the development of technology will always be in the direction of human friendly. People's future demand for display equipment is more portable, more fashionable, and more environment-friendly. Therefore, to manufacture lighter, thinner and softer products and improve the image quality while consuming lower power consumption is the main problem that researchers and industry need to face. The emerging flexible active matrix display (FOLED) technology under development fully meets all the above requirements. Compared with ordinary hard screen display, flexible display has many advantages: impact resistance, stronger seismic resistance; light weight, small volume, fully folding, more convenient to carry; using tape rolling manufacturing process similar to newspaper printing process, the cost is lower etc. The basic structure of FOLED display screen is "flexible substrate/ITO anode/organic functional layer/metal cathode". Its luminous mechanism is similar to that of ordinary glass substrate.

The structure of a flexible display device is shown in Figure 2. The flexible display device consists of the three layers. Those are the anode, the cathode and the insulating layer. The anode and the cathode are aluminum and nickel, respectively. Polyimide is chosen as an insulating material because of high dielectric breakdown voltage. The discharge occurs when the voltage is applied between the anode and the cathode.

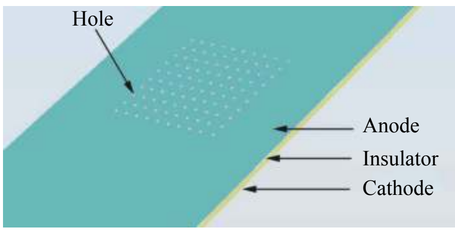

Fig.2 Structure of the flexible display device

According to the Paschen 's Law, breakdown voltage depends on the gas pressure and the electrode gap[14]. In a hollow cathode discharge, the cathode is a hollow structure. The discharge development in three stages dependents on the discharge current. Those are pre-discharge, hollow cathode discharge and abnormal glow discharge. The hollow cathode discharge in a cylindrical geometry depends on the gas pressure and the cathode hole diameter.

Display technology based on flexible organic electroluminescent materials, adopts active image quality reconstruction and adaptive camouflage method, using flexible display devices combined with emissivity control layer and temperature control layer as the target camouflage barrier equipment, in the process of target activity shoot the background in real time, displaying the background image on the camouflage obstruction equipment, segmenting the target heat map through the emissivity control layer and the temperature control layer to achieve all-weather, the whole process is highly integrated with the surrounding natural background, so as to achieve intelligence, adaptation and active camouflage effect.

4 Conclusion

In this study, the background image of the target movement is displayed on the flexible obstructing equipment in real time, and the optical characteristics of the target are changed by modulating the emissivity of the flexible obstructing equipment. Combined with the active image quality reconstruction technology, flexible display and emissivity control layer achieve the purpose of suppressing the infrared emission intensity of the target and segmenting the target heat map, so as to achieve the all-weather, full-process dynamic and static state of the target, facility and equipment camouflage effect.

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