

# Research Progress on New Technologies of False Targets

Yipeng Yin, Zhongbei Zhao, Jiacheng Cao, Jun Ma\*

Airforce Logistics Academy, Jiangsu, Xuzhou, 221000, China

\* Corresponding Author Email

**Abstract.** To counter new detection technologies, decoy technology has evolved from the previous relatively simple combination of camouflage, infrared and radar coatings or materials to a comprehensive technology that integrates 3D simulation technology, new materials, intelligent temperature control, complex electromagnetic countermeasures and multi-dimensional coordinated deception. This paper reviews the simulation decoy technology in the four aspects of visible light, infrared, radar and laser, and summarizes the development trends of new decoy technologies.

**Keywords:** False targets; New technologies; Research progress.

## 1. Introduction

Camouflage technology includes two aspects: "hiding the truth" and "showing false". The degree of simulation and the quantity of the false target are proportional to the survival probability of the real target. The false target technology simulates the physical, electromagnetic, thermal and other characteristics of the real target to deceive the enemy's reconnaissance and attack systems, which is the core means of "hiding the truth and showing false" on the modern battlefield. In recent years, with the integration of multiple disciplines and breakthroughs in intelligent technology, the false target technology has made significant progress in multi-spectrum integration, dynamic simulation, algorithm simulation-driven, and material innovation.

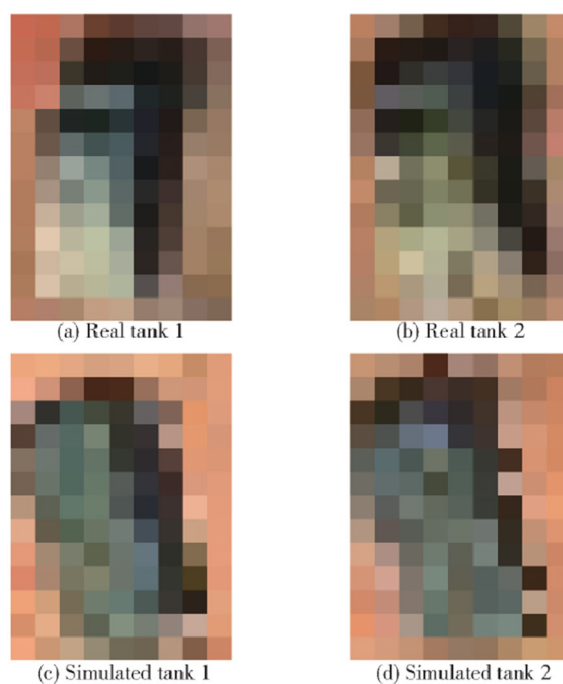
## 2. New Visible Light Simulation Technology

Visible light simulation mainly uses camouflage pattern design and color matching to achieve the simulation of false targets. The purpose of implementing visible light simulation is to enhance the deception and confusion of the false target in visible light reconnaissance and attack by enemy detection equipment (including the naked eye and multi-dimensional reconnaissance lock-out equipment), so that our side's targets can obtain a higher survival probability on the battlefield. The following are the main new technologies:

(1) Three-dimensional modeling simulation image generation technology. Ground mobile false targets mainly consist of vehicles, including tanks, transport vehicles, etc., and in addition, the aviation department also has aircraft and other mobile false targets. For mobile false targets, the simulation degree in terms of shape and color needs to be improved. To improve the efficiency of the simulation performance test of the false target in the visible light band and reduce the test risk, the research is based on the simulation performance test of the false target using a real tank as the research background, and by applying three-dimensional modeling technology and simulation technology, the purpose of replacing the real tank with a simulated tank is achieved [1]. Through coordinate transformation and rendering, the efficiency of the simulation performance test of the false target in the visible light band is improved, and the three-dimensional model of the tank is converted into a two-dimensional image under the test conditions, using the input of collection parameters and the pre-set rendering of the three-dimensional tank model functions to obtain the simulation test image of the tank false target. Through similarity calculation, the mean similarity degree of the features between the simulated tank image and the real tank image reaches 87.5%, and it provides support for the multi-band simulation performance test of the false target Figure 1.

(2) Three-dimensional and two-dimensional image synthesis technology. By collecting the three-dimensional point cloud data of the real tank using three-dimensional modeling technology, selecting

appropriate methods to model the main components of the tank, and using flexible mapping methods to map the digital camouflage patterns onto the three-dimensional simulation model, the simulation tank is constructed. Through coordinate transformation and perspective projection transformation, the three-dimensional tank model is combined with the two-dimensional background to obtain the simulation experiment image. By calculating the similarity quantification indicators of the simulation experiment image between the simulated tank and the real tank, the average comprehensive similarity degree of the two is 87.507%, and according to the statistical analysis of the interpretation officer on the simulation experiment image, the probability that the simulated tank has the features of the real tank reaches 96.3% [2,3]. The related simulation technology can be applied to other industries for high-simulation false targets, such as oil and ammunition equipment, etc., mobile false targets.



**Figure 1.** Screenshot of the software for identifying real and fake tank targets [1]

(3) Evaluation of camouflage effect. Based on the purpose of optical camouflage, digital patterns can be used to camouflage equipment. This method can overcome the shortcomings of smooth edges and distinct boundaries in traditional camouflage, making the edges between different colors blur and achieving good color blending effect, which is more conducive to integrating with the target background. This can lead to better camouflage effects for ground equipment. Relevant studies have shown that through the segmentation of equipment surface patterns and color design, a better simulation effect can be achieved. Using digital camouflage evaluation software or methods [4,5] can effectively evaluate the color simulation effect of fake targets. Such methods can be used for the simulation assessment of other digital camouflage fake targets or for evaluating the visible light camouflage effect.

### 3. New Infrared Simulation Technology

Infrared simulation refers to simulating the infrared radiation characteristics of objects (such as radiation intensity, spectral distribution, temperature field distribution, etc.) to make them present similar or specific signal characteristics to real targets in infrared detection equipment (such as infrared thermal imagers, infrared guided missiles, etc.). This technology is widely used in military camouflage, target identification, infrared equipment testing, industrial inspection, medical diagnosis, etc. There are the following new developments:

(1) Electrothermal coating technology. Electrothermal coatings can effectively improve the deception effect of fake targets. According to relevant deception theories and experimental research, it has been found that the temperature of the fake target coated with electrothermal coatings is about 5°C higher than the background during continuous power supply [6], solving the problems of design and preparation of different resistivity gradient electrothermal coatings and large-scale application. This makes the fake target have significant infrared radiation characteristics.

(2) Resistive array infrared simulation technology. To realize a fake infrared device that can provide different infrared signals for different equipment, controlling the infrared radiation of an array of resistive elements is a feasible method. Experimental results show that by selecting resistors and medium materials with small mass and small specific heat capacity, the rise and fall time of resistors can be reduced, and the speed of pattern transformation of the infrared display screen of the resistive array infrared fake target can be increased to deceive the enemy's reconnaissance, detection and guidance systems, achieving the purpose of protecting important military targets or confusing the enemy [7].

(3) Infrared image simulation technology based on electrothermal film. The simulation of infrared images can test and evaluate the real-time performance of infrared detection systems and can also be used for infrared camouflage, such as setting fake targets. Simulation experiments have found that using electrothermal films can form infrared images, and the infrared images of the fake target are similar to the original target images, with a correlation coefficient of 0.5 or above, and the shapes are mostly the same [8]. There are many advantages of using electrothermal films to simulate infrared images on fake targets, such as small volume, light weight, convenient temperature control, simple system, low cost, easy processing, and the ability to form various shapes of thermal infrared images, and fast imaging speed.

(4) Real-time battlefield environment infrared image generation technology based on JRM. To meet the performance requirements of the new generation infrared imaging target simulation system, to provide realistic battlefield environment infrared images for infrared imaging guided weapons for semi-real simulation experiments, a method for generating battlefield environment infrared images based on JRM has been studied. According to relevant experimental research, high-quality and realistic infrared seeker field-of-view images have been realized according to the requirements. This experimental result has certain reliability and meets the real-time requirements, and can provide infrared images with different ground object backgrounds, different strike targets, and different interference environments in the laboratory environment [9].

(5) Evaluation method for the infrared deception and interference efficacy of fake targets based on GBVS. Compared with the visible light band, the differences between real and fake targets in the infrared band are usually more obvious. Combined with the GBVS visual saliency model, by comparing the saliency contrast of the real target and the fake target in the same background, the infrared deception and interference efficacy of the fake target can be quantitatively evaluated [10]. According to experimental research, regardless of whether the target posture and shooting angle change, this method can always quantitatively reflect the infrared deception interference efficacy of a single false target and distinguish the infrared deception interference efficacy of different types of false targets. The results of this evaluation method are not only objective and comprehensive, but also can promote the improvement of false target performance, and greatly ensure the battlefield initiative of our military.

#### **4. New Technologies in Radar Simulation**

Radar simulation is a technology that reproduces the working process, target characteristics, and environmental interaction of radar systems in different scenarios through modeling and simulation techniques. Its core is to simulate the radar signal's transmission, propagation, reflection, and reception processing through mathematical models, algorithms, and software and hardware systems,

for the purpose of verifying radar design, testing performance, and evaluating anti-interference capabilities. The following are new technologies:

(1) Multi-antenna synthetic false target electromagnetic interference technology. Based on the mathematical mechanism of multi-antenna synthetic false target interference technology as the theoretical basis, experimental tests were conducted, and it was found that the three-element system has the ability to interfere with radar angle measurement, and it was confirmed that the three-element antenna has a strong interference effect on the geometric center of the bistatic angle measurement radar [11]. This experimental result provides engineering experience and technical support for the application of multi-antenna synthetic false target electromagnetic interference technology.

(2) Phased array radar and networking anti-active false target and false track method. Active multi-false target interference is essentially a suppression interference, by covering the real target with the number of false targets. Active multi-false target interference will affect the target detection and target tracking links of phased array radar, and active multi-false target interference uses part or all of the radar information and is highly correlated with the radar transmitted signal. With the increase of the randomness of false target parameters and the increase in the number of false targets, the interference has the characteristics of both active suppression interference and active deception interference [12]. In addition, when the arrival time difference between the target echo and the false target echo is less than the radar resolution, signal interference occurs, and the existence of interference indirectly increases the detection probability of the real target.

(3) Frequency stepped continuous wave radar dual-frequency electromagnetic radiation false target technology. Based on theoretical analysis and effect experiments, the characteristics of false targets in the dual-frequency electromagnetic radiation of frequency stepped continuous wave radar were analyzed. It was found that single-frequency electromagnetic radiation can cause a single position-random "hills" type false target in the frequency stepped continuous wave radar [13]. And without considering intermodulation interference, dual-frequency electromagnetic radiation can cause two position-random "hills" type false targets in the frequency stepped continuous wave radar, and the distance difference between them is related to the frequency difference of the dual-frequency interference signal.

(4) Distance and angle joint deception interference method for radar tracking confrontation. In radar confrontation environments, in response to the limitations of the single interference dimension of distance gate dragging interference and the limited interference direction, and the insufficient interference effect caused by the insufficient utilization of false target space, the combination of angle deception and distance deception is formed to form distance-angle joint deception interference. At the same time, an evolutionary algorithm is used to optimize the interference strategy. The various methods adopted in the experimental research can effectively meet the requirements of different interference effects [14].

(5) Pseudo-random Doppler false target interference technology for STAP radar. The signal model of radar STAP was established, and then the mathematical model of pseudo-random Doppler false target interference was analyzed and compared in terms of noise interference and pseudo-random Doppler false target interference. The interference efficacy was studied, and the simulation results showed that compared with noise interference, pseudo-random Doppler false target interference has a good interference effect on STAP [15]. This research can provide technical support for future research on STAP interference.

(6) Simulation technology for generating dense false targets and extracting feature vectors. Dense false targets are a new type of active deception interference. This article elaborates on the working principle and advantages and disadvantages of DRFM, mainly exploring the need to set up multiple different angles for simulation after establishing the false target model when building dense false targets at different distances and angles. The feature vectors that need to be clustered are extracted. It is concluded that the false targets generated by DRFM not only have strong processing capabilities for wideband signals, but also have high fidelity storage capabilities [16].

## 5. New Laser Simulation Technology

Laser simulation is a technology that digitally reproduces the laser's emission, transmission, scattering, target interaction, and detection processes in a specific environment through modeling and simulation techniques. Its core is to precisely simulate the working principle, environmental impact, and target characteristics of the laser system using mathematical models and computer algorithms, and can be used for laser false target simulation technology.

(1) Configuration method of laser protection false targets for long-shaped military targets. Starting from the particularity of protecting long-shaped military targets, based on the analysis of the effective protection area of a single diffuse reflector plate, this paper discusses the number of false targets required to protect long-shaped military targets in laser active angle deception interference, and establishes a model for false target configuration. This new method for protecting long-shaped targets through laser interference source is of certain reference value and borrowing significance for the research on long-shaped target protection technology [17].

(2) Laser false target deployment technology under complex terrain conditions. Laser false target deployment is an important part of laser angle deception interference methods. By using a reasonable deployment scheme, the minimum number of false targets should be used to achieve comprehensive protection in the designated airspace. The particle swarm algorithm is used to optimize the solution for the problem of laser angle deception interference false target deployment under complex terrain conditions. The results of the generated deployment schemes in different application scenarios show that the optimization algorithm has good feasibility and adaptability for the problem of false target deployment, and its optimization results can provide assistance and reference for decision-makers [18].

(3) Selection technology of natural terrain false targets in laser angle deception interference. Laser angle deception interference is an effective means to counter semi-active laser-guided weapons. By establishing a false target interference energy distribution model for natural terrain, this paper studies the influence of the inclination angle and threat angle of natural terrain on the interference energy received by the seeker from natural terrain false targets. According to the simulation experiment research: in the same conditions, the interference energy reflected by sandstone-like natural terrain false targets is higher than that of building-like false targets. Moreover, when using sandstone-like natural terrain false targets for protection, the inclination angle of the natural terrain required is at least greater than  $31^\circ$  [19]. This research result has certain guiding significance for the selection of natural terrain false targets.

(4) Research and design of new laser false targets. Laser deflection interference is a commonly used active deception interference method and an effective means to counter semi-active laser-guided weapons. To improve the combat effectiveness of laser decoys and make up for the shortcomings of the current several commonly used false targets, two laser false target methods, namely, companion unmanned aircraft and fiber laser decoys, are proposed. The characteristics and usage methods of these two methods are studied [20]. The adjustable and controllable laser false targets are realized, making the use of false targets more flexible and reliable.

(5) Deployment method of laser angle deception false targets without overhanging areas. Research has been conducted on the problem of false target overhanging areas, and a method of using two false targets to cover the overhanging area with their effective protection zones has been proposed. The feasibility of four false target deployments to achieve all-round protection without overhanging areas has been calculated and demonstrated. A practical and feasible specific deployment method has been given, such as deploying four false targets at  $0^\circ$ ,  $40^\circ$ ,  $180^\circ$ , and  $220^\circ$  azimuths [21], which can avoid the formation of overhanging areas, ensuring the safety of the protected targets and being simple and fast.

## 6. Conclusion

The advanced target simulation technology is evolving from "static simulation" to "dynamic intelligence" and from "single spectrum" to "all-dimensional integration". Its core driving forces include interdisciplinary innovation (such as metamaterials, AI) and practical demand traction (such as anti-precision guidance, electronic countermeasures). In the future, with the penetration of technologies like 5G/6G and quantum computing, the false target will achieve breakthroughs in distributed collaboration, high-power confrontation, and intelligent decision-making, becoming a key means to shape battlefield offensive and defensive advantages.

## References

- [1] Feng Haichao, Wang Yuenet, Zhang Zeyan, et al. Research on Simulation Technology for Tank False Targets' False Appearance Performance [J]. *Science and Technology Innovation*, 2022, 21: 169-172.
- [2] Feng Haichao, Wang Yuyu, Liu Wei, et al. Simulation Technology for False Appearance Performance of Tank False Targets Based on 3D Modeling [J]. *Journal of Ballistics Research*, 2021, 42(09): 1998-2003.
- [3] Yu Jun, Shuang Xiao, Hu Zhiyi, Su Haitao. Digital Camouflage Technology Based on Optical Camouflage [J]. *Computer and Digital Engineering*, 2011, 39(12): 142-146.
- [4] Hou Lei, Yu Jun, Chen Ding. Research on Evaluation Method of Digital Camouflage Concealment Effect [J]. *Foreign Electronic Measurement Technology*, 2013, 32(2): 23-25.
- [5] Wei Wenbin, Peng Ruihui, Sun Dingsheng, et al. Active False Target Identification Method Based on Multi-phase Processing Interval Frequency Response Feature Clustering [J]. *Journal of Electronics & Information Technology*, 2024, 46(7): 2721-2731.
- [6] Yang Hui, He Chao, Pan Jiali, et al. Application of Electrothermal Coatings in Infrared False Appearance [J]. *Journal of Ballistics Research*, 2021, 42(1): 118-123.
- [7] Fan Fan, Tian Changhui, Yang Baiyu, et al. Research on Transformation Relaxation Time of Infrared False Target Arrays Based on Resistance Arrays [J]. *Journal of Electronic Engineering Institute*, 2019, 8(5): 119-122.
- [8] Chen Hongye. Simulation of Infrared Images Based on Electrothermal Film. *Infrared Technology* [J]. 2013, 35(10): 650-653.
- [9] Zhong Guozhi, Liao Shouyi, Yang Xinqie, et al. Real-time Generation of Battlefield Environment Infrared Images Based on JRM [J]. *Infrared Technology*, 2023, 46(2): 183-189.
- [10] Qiu Yongjia, Cheng Zhengdong, Zhao Dapeng, et al. Evaluation of Interference Efficacy of False Targets Based on GBVS for Infrared Deception [J]. *Laser and Optical Electronics Progress*, 2023, 60(12): 1-6.
- [11] Ning Yuhang. Experimental Research on Synthetic Multi-Antenna False Target Electromagnetic Interference Model [D]. University of Electronic Science and Technology of China, 2022.
- [12] Zhao Yuan, Xiangchang Array Radar and Networking Anti-Active False Target and False Track Method Research [J]. 2019, 19-20.
- [13] Zhao Kai, Wei Guangui, Wang Tao, et al. Feature Analysis of Dual-Frequency Electromagnetic Radiation False Targets in Frequency-Stepped Continuous Wave Radar [J]. *System Engineering and Electronics Technology*, 2023. 45(5): 1315-1322.
- [14] Fu Lianjian. Distance-Angle Joint Deception Interference Method for Radar Tracking Countermeasures [D]. University of Electronic Science and Technology of China, 2023.
- [15] Yang Aiping, Hu Zehui, Sheng Shaosong, et al. Research on Pseudo-Random Doppler False Targets Interference for STAP Radar [J]. *Ship Electronic Countermeasures*, 2023, 46(4): 14-18.
- [16] Zhao Ruilang, Lu Jianye, Chen Wei, et al. Research on Generation of Dense False Targets and Feature Vector Extraction [J]. *Image and Signal Processing*, 2022, 11(2): 68-78.
- [17] Shen Tao, Liu Zhiguo, Gou Xiaotao, et al. Research on Configuration Method of Laser Protective False Targets for Long-shaped Military Targets [J]. *Laser and Infrared*, 2021, 46(8): 989-993.
- [18] Xin Cheng, Wang Yafu, Zhou Quan, et al. Research on Deployment Problems of Laser False Targets under Terrain Conditions [J]. *Laser and Infrared*, 2017. 47(7): 875-878.

- [19] Huang Jianshe, Shen Tao, Yang Yang, et al. Research on Selection of Natural Landmarks for False Targets in Laser Angle Deception Interference [J]. *Optics and Spectroscopy Analysis*, 2022, 42(9): 2965-2966.
- [20] Ji Qiang, Zong Siguang, Yang Jianbo, et al. Research and Design of New-Type Laser False Targets [J]. *Laser and Infrared*, 2022, 51(9): 1212-1216.
- [21] Lu Song, Yang Wen, Yang Baocui, et al. Research on Deployment Method of Laser Angle Deception False Targets without Overhead Zone [J]. *Optics and Photoelectric Technology*, 2016, 14(5): 38-41.