Thermal vision: lessons and way-outs

Pavel Zahradnicek, Jan Hasik
University of Defence, Brno, Czech Republic
pavel.zahradnicek@unob.cz

Abstract: *Thermal vision, since 2022, has started to be more widely utilized as a tool in security. The Ukrainian conflict showed us how to use it in practice. The article presents lessons from this conflict. The main chapters deal with questions of how thermal vision influences the activities of combat units. The authors are studying this phenomenon from the perspective of the theory of military tactics, supported by their own experiments and experiences.*
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1. Introduction

In 2022, the Ukrainian conflict escalated. In this year, the authors prepared an article about the development and utilization of thermal vision as a progressive sensoric device [1]. After three years, the conflict rapidly sped up the tempo of military industry and development. Applications, like thermal vision, aerial and ground drones, artificial intelligence, and others, are widely utilized in this conflict. Competing sides are making lessons from combat and improving their devices, tactics, techniques, and procedures in order to win the battles. Personal cameras and scopes created technological advantages in the first two years and enabled the defenders to stop the formation of units. Thermal visions are commonly utilized as parts of FPV drones. They speed up the OODA loop [2]. The operational tempo is faster, and the frequency of tactical activities [3] is not blocked by lack of information from the battlefield.

2. Lessons regarding to thermal vision

As was mentioned, thermal vision as a sensoric part of drones is usual. The thermal vision can detect the object; the identification is related to many factors. The problematic time periods are sunrise and sunset, when the thermal vision does not work properly and the daytime camera also does not. In summertime, the contrasts are not so sharp, and it makes detection less effective.

Operating thermal vision devices is a usual part of the skillset of frontline operators. Minimally 1/3 of personnel are able to operate various drones at a basic level. Detection and identification are part of the reconnaissance skillset of individuals.

Thermal devices need to be recharged. Commercial personal devices have “playtime” of approx. 3 hours, related to temperature. In the front line, it is necessary to dispose of smart battery management. Every single soldier and every unit is equipped with a power bank. The problem is that electric generators are visible in the thermal spectrum and need to be dug in the ground, far from positions of operators. Therefore, real battery management is a challenge for future operations.

From the perspective of the necessity to stay hidden, we can speak about the “battle against heat signature detection” [4]. Camouflage against thermal devices has to dispose of multiple layers. Nowadays, necessary equipment is thermal cover-foliage with an upper camouflage layer. There exist more approaches, but the main goal is to cover heating parts.

Because the battle zone is extremely lethal, the thermal devices are fastened on telescopic sticks and connected via Bluetooth technology with a screen, usually a cellphone. Operators can be in safe positions and scan his sector of observation. When important pictures and positions are identified, the cellphones enable almost real-time sharing again, acting according to the OODA loop.

The thermal devices can detect the routes newly utilized, track the avenues, and last, vehicles and operators. This ability can eliminate maneuvering and the momentum of surprise.

Fusion of technologies is newly and widely used. The devices are adequate for personal utilization, and the computing part was miniaturized. These devices enable the combination of inputs from daily cameras, night vision, and thermal vision. The output is more realistic. In thermal vision, non-heating parts can merge with surroundings; night vision does not show thermal contrast. Advantages are combined together.

Picture1: *Demonstration of fusion technology*

Source: amazon.com

The thermal vision filled with white phosphor and elements of augmented reality is newly utilized, especially by Special Forces. This makes night orientation extremely easy compared to simple thermal vision.

Picture 2: *Demonstration fusion technology with WP and AR*

Source: LinkedIn [5]

When fighting, the smoke and other harmful things are present. The thermal vision can partially see through the smoke wall and, in combination with advanced technologies, makes the situational awareness more clear [6].

A thermal weapon sight can be connected with personal goggles or a smartphone. Therefore, precise firing from small arms can be realized without unhiding the figure of the operator. This possibility can be utilized in a static type of action but can contribute to saving lives.

3. Wayouts for future

Thermal vision will be commonly used.

Thermal vision will be commonly used. In the near future, miniaturized fusion will replace thermal vision. The day camera, night camera, and thermal camera can be combined as a sensoric head of drones, rockets, and detectors.

Artificial intelligence, based on databases of objects, will specify the targets and can give more specifics for decision-making of operators or commanders.

Personal camouflage for future combat is significant and essential. The new, modern smart combat suit will be equipped. Cooling can also be part of camouflage. The authors agree with the approach mentioned in [4], where:

- As thermal imaging technology advances, so too must the strategies for staying undetected. One of the most exciting developments in this area is adaptive thermal camouflage, which has the potential to enable operators and equipment to modify their heat signatures in real time. Although it is still under development, this breakthrough is set to transform how we approach thermal concealment in the future.
- In addition, nanotechnology and AI-driven camouflage are paving the way for enhanced stealth capabilities. These advancements aim to produce combat uniforms that can adjust their thermal output dynamically, allowing for seamless blending with the environment. While adaptive thermal camouflage focuses specifically on real-time heat signature adjustments, these advancements promise to offer a broader range of dynamic stealth features, taking concealment to the next level.
- Nevertheless, as AI-driven surveillance technology progresses, traditional methods of concealment are becoming increasingly ineffective. To keep up, strategies such as heat signature spoofing, decoys, and AI-driven counter-surveillance will become essential, working alongside physical camouflage to maintain an advantage against detection.

The problem of combat identification of infantrymen can be solved. The idea needs fully equipped operators with advanced fusion with the support of AR or AI. The specific shapes have to be painted in battledress. These shapes, not visible in thermal or night and not well in daily spectra, can be identified after AT/AI. It means whoever is not equipped with these shapes is a different person.

In the figurative sense, combat identification is a crucial problem for autonomous deployment of unmanned vehicles, because they are not able to recognize enemy and own troops without specific identification. This advanced technology and development can make this system more autonomous.

4. Conclusion

Not thermal vision, but fusion will be a technology of future. Long lasting conflict will continue speeding the development. New techniques and approaches will be important to adopt. The research has to focus not only on technology, but also on utilisation, organisation and training. To have advantage, it is necessary to experiment directly in field (or battlefield).

New concepts of vision systems, camouflage systems including personal clothing systems will be developed hand in hand. Mentioned ideas are basics for future research of authors and are based on individual experiences.

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