Perspective

Social Radars: Finding Targets in Cyberspace for Cybersecurity

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INSPIRED by the insight from American political scientist Lasswell, who summarized the environmental role in societal surveillance [1], Schramm coined the term "social radar" [2] as it resembles the activities of radar in collecting and processing information, playing a crucial role in helping humans perceive changes in the internal and external environment and promptly adjusting adaptive behaviors. Against the backdrop of cyberspace security becoming a global focus, the development of globalization in information and intelligence calls for in-depth research into social radar. This can help us better understand and respond to complex societal dynamics more intelligently and sensitively. Social radar, as the capability to keenly observe and interpret this information, aids in a better understanding of societal trends, cultural evolution, and interpersonal interactions. This sensitivity is crucial for timely grasping societal changes and predicting trends. In the 2010 "Arab Spring" event, social media played a crucial role in driving the movement, resulting in widespread violent conflicts that had significant impacts on both society and the economy [3]. This event re-introduced social radar as a service platform based on social networks and social media. It aims to employ keyword expansion detection modules and sentiment analysis tools to summarize specific social dashboards in Fig. 1. The generated results assist authorities in planning "risk control strategies," issuing alerts to businesses or governments, and monitoring unexpected occurrences [4]. The research on social radar provides robust support for us to better adapt to and lead technological changes, enabling us to keenly perceive the pulse of societal development and make wiser decisions.

Fig. 1. A Social Radar Capable of Perceiving the World.

This perspective comprehensively discusses the definition and applications of social radars, exploring how radar can be mapped onto the social landscape through a functional classification approach. Additionally, grounded in the Cyber-Physical-Social Systems (CPSS) theory, the perspective introduces a comprehensive perception system. This system is capable of acquiring data across diverse spatial dimensions and integrating information from different modalities.

In the realm of politics, a social radar plays a crucial role in analyzing and predicting public cognition, attitudes, and behaviors to enable government agencies to intelligently engage with and respond to societal dynamics [5]. A similar advantage is evident in the business domain, where social radar, through the monitoring and analysis of social media, news, and other public information sources, provides real-time insights into consumer trends, market responses, and brand reputation [6]. Radar, as a key technology in the military domain, offers the military formidable sensing and command control capabilities through functions such as target detection and tracking, air defense, and more. Complementing this, social radar monitors and analyzes social culture, public sentiments, and leadership intentions to provide predictions and insights into societal reactions that military actions might elicit [7]. Cao *et al*. [8] proposed a Traffic Sentiment Analysis (TSA) system, which is capable of collecting and analyzing the wisdom and opinions of the public, taking into account human emotions. This enhances the perception, computation, and decision-making capabilities of intelligent transportation systems. This perspective supports the necessity of introducing

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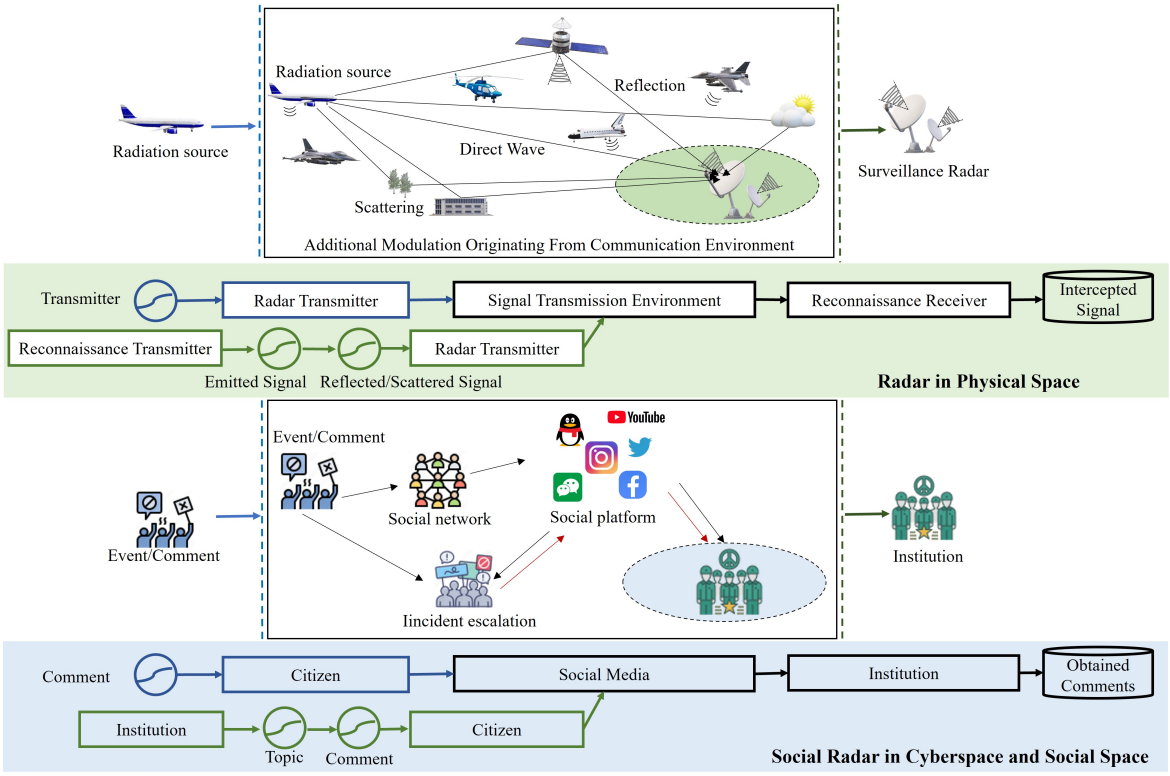

Fig. 2. Radar in Physical Space (Top); Social Radar in Cyberspace and Social Space (Bottom).

social radar in the field of intelligent transportation. Costa and Boiney [9] described an analytical framework based on social platforms and news. Maybury [7] outlined the workflow of social radar architecture. Despite existing research mentioning the use of social radar to perceive societal information, there is a lack of in-depth analysis regarding the relationship between social radar and traditional radar. This impedes a deeper understanding of social radar and the enhancement of its application levels by revealing the interactions between social factors and the physical environment. This perspective conducted a one-to-one mapping analysis between radar and social radar to validate its accuracy, reliability, and enhance its practical feasibility. By combining social radar with traditional radar, a comprehensive perception framework is further proposed for radar and social radar in physical, social, and cyber spaces.

The Mapping of Radars to Social Radars

In order to deepen the understanding and conduct a comprehensive study of social radar, thereby enhancing its application feasibility, the radar in physical space [10] is mapped to social radar in the online social space [11]. Based on the operational modes of radar, it can be categorized into active radar and passive radar. The same categorization applies to social radar, as illustrated in Fig. 2. The upper part outlines the workflow of passive radar in physical space, where emitted signals originate from radiation sources, undergo reflection, scattering, or are directly received by surveillance radar. It is a radar system that detects and tracks targets by receiving signals in a non-cooperative environment. The green portion outlines the workflow of both passive and active radar. Unlike passive radar, surveillance radar (active radar) actively emits radio waves into the external environment, and upon encountering targets, the reflected waves are received, providing information on the location and velocity of objects. A similar principle is applicable to social radar in cyberspace and social space. In active social radar, an organization initiates a topic, and citizens express their opinions, emotions, or positions through social media [12]. Other citizens can quickly see these comments through social platforms, potentially generating new ideas. The organization gathers and analyzes citizen comments and data to provide support for potential decisions.

In terms of communication environments, physical space radar needs to adjust based on environmental conditions to achieve adaptive domain responsiveness [13], ensuring the provision of reliable and accurate information. Similarly, social radar requires tagging, calibration, and correlation to perceive a wide range of phenomena (such as political, social, economic, health, and environmental aspects) and potentially predict trends in human cognition and behavior changes. The social radar should not only be attuned to the magnifying impact of personal and communal thoughts and emotions but also must possess cultural awareness, as behavioral patterns may be influenced or molded by cultural values [7].

In the military domain, physical space radar detects military targets such as aircraft, ships, command and control facilities, and troops. In the cyber and online space, radar is used to discover the cognition, intentions, behaviors, hopes, fears, and dreams of civilians and leaders. This combination of soft and hard power enables leaders to make better decisions.

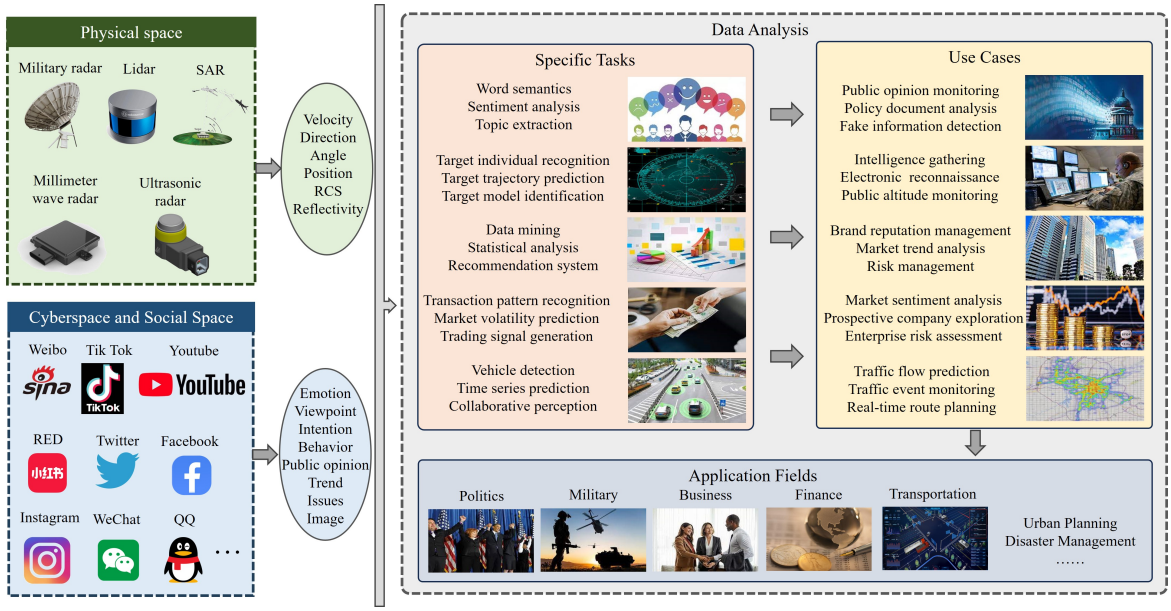

Fig. 3. Comprehensive Perception Framework Based on CPSS.

A Comprehensive Perception Framework

Based on the CPSS [14]–[16], we have constructed a comprehensive perception framework that integrates radar and social radar, as shown in Fig. 3. In the physical space, various types of radar can detect parameters such as the speed, angle, position, and direction of targets [17], [18]. Simultaneously, in Cyberspace and Social Space, data related to citizens' emotions, viewpoints, and opinions. These parameters and data are subsequently cleaned, aggregated, and structured for further analysis. Moreover, integrating this perception system with the TRUE DAO system [19] based on parallel intelligence achieves comprehensive perception from the physical space to the social space. Leveraging parallel intelligence, the system can intelligently analyze vast amounts of data and make integrated decisions within the TRUE DAO framework, thus effectively addressing complex scenarios. This fusion enables a higher level of intelligence, automation, and integration, thereby providing more robust services and support.

Deep learning [20]–[22] has demonstrated remarkable performance in various tasks, particularly with the emergence of pre-trained large models in recent years [23], [24]. These models exhibit excellent adaptability in downstream tasks, both within single modalities and across modalities, following fine-tuning [25]. These tasks include but are not limited to sentiment analysis, semantic segmentation, object detection, and relation extraction [26]. The data processing capabilities of deep learning have facilitated widespread applications of cross-modal data in fields such as politics, military affairs, commerce, finance, and transportation.

Public opinion monitoring enable governments to promptly identify abnormal situations and take action before the situation worsens. This is achieved by employing methods such as sentiment analysis and topic extraction to quickly comprehend vast amounts of data. In the military context, information is a crucial support for strategic planning, and the intelligence gathering process spans the entirety of a war. However, the information density that can be carried by a single information source is limited. Radar, a commonly used electronic reconnaissance method in the military, receives electromagnetic waves actively or passively and can discover the combat targets of the enemy, accomplishing functions such as individual target identification and target trajectory prediction. Nevertheless, in conflicts such as the war between Russia and Ukraine, the attitudes of civilians are also crucial in determining the outcome of the war [27]. Through social radar, decision-makers can detect information flows in society early on, providing support for subsequent strategic planning.

In the business and financial domain, social radar provides companies with powerful market insights and real-time intelligence. By monitoring social media, news, and online forums through collaborative filtering or graph neural network algorithms [28], companies can gain in-depth understanding of market dynamics, consumer feedback, and competitive landscape. This enables precise targeting of the audience [29], improving marketing effectiveness, and promptly identifying and addressing potential crises to protect brand reputation. Additionally, social radar offers insights into business and financial activities, assisting in the formulation of more competitive strategies and investment decisions.

Collaborative perception has become a crucial research direction in intelligent transportation, utilizing the collective fusion perception of sensors such as millimeter-wave radar, lidar, and cameras installed on vehicles, other vehicles, and road test devices. Social traffic emphasizes the full utilization of online and interactive big data for real-time computation and embedded applications within the transportation system [30]. Combining social traffic with social radar enables real-time responsiveness to traffic conditions through the real-time computation facilitated by social radar data. This inte-

gration provides intelligent and personalized services for the transportation system. It allows for the coordination and optimization of traffic flow, improving system efficiency, rapidly identifying and alleviating traffic issues [31]. This brings a higher level of coordination and intelligence to urban traffic, enhancing the travel experience and achieving a safer and more efficient city transportation system [32].

In this perspective, a thorough analysis is conducted to summarize the mapping relationship between radar and social radar. Based on the CPSS theory, we constructed a comprehensive perception system. This system integrates data obtained from radar and social radar across different spaces. Our objective is to provide institutions with more comprehensive and real-time decision support, enabling them to better understand and promptly respond to the complex and dynamic societal environment with greater accuracy. In the future development of social radar, it plays a crucial role in connecting various aspects of an intelligent society, providing profound significance in building a smarter and more responsive community. This involves not only a sensitive observation of societal dynamics and risks but also an intelligent interpretation of multiple layers, including cultural evolution and individual interactions. Social radar is poised to become the driving force behind the new era of intelligence, leading us towards a future that is more equitable, intelligent, and sustainable.

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