ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

Analysis of Research Hotspots and Development Trend of Domestic Manned/Unmanned System Cooperative Warfare Issues

Jianyong Weng[1,*], Qiwu Wu[2], Xiaohang Lu[3]

[1]Postgraduate Brigade, Engineering University of PAP, Xi'an, 710086, China

[2]School of Equipment Management and Support, Engineering University of PAP, Xi'an, 710086, China

[3]Postgraduate Brigade, Engineering University of PAP, Xi'an, 710086, China

[*]Corresponding author: 985333709@qq.com

Abstract

In order to fully understand the current comprehensive development of the manned/unmanned system cooperative operation (MUMT) problem, the current domestic research in this field is analyzed by using Citespace and Tableau, with a view to supporting the prediction of the future development trend. It is found that, against the background of rapid development of informatization, unmanned and intelligentization, the research on issues related to manned/unmanned coordinated warfare is becoming more and more common, with the space ranging from the air to the sea, from the surface to the underwater and then to the ground, and the outreach of the research content is also becoming more and more rich, which mainly involves the planning of operational missions, generation of operational capabilities, operational technology requirements, and exploration of the operational modes, and so on. In the future, manned/unmanned combat will be the main mode of war, which has been confirmed by the Russian-Ukrainian war, but how to conduct more systematic and comprehensive in-depth research and precise and efficient deepening of the application will be directly related to the victory or defeat of the future war.

Keywords

Manned/unmanned; Cooperative operations; Citespace; Tableau.

1. INTRODUCTORY

With the steady advancement of military informatization and intelligence, various new technologies have been applied to combat systems, and informatized and intelligent warfare will become the main form of future warfare. Unmanned combat system has become a subversive weapon in the new type of war, showing unique advantages in reconnaissance, fire guidance and strike, search and rescue and other diversified combat tasks. At present, some of our special forces have already started to issue unmanned weapons and equipment and form "mixed" battle teams. Due to the limited level of intelligence of unmanned systems, they cannot completely replace human thinking and judgment, and manned/unmanned system synergy will become the new normal of unmanned system application in the future battlefield.

Manned/unmanned coordinated combat (hereinafter referred to as "coordinated combat"), is born to adapt to the new battlefield environment and style, is the mechanization, informationization, intelligent integration of a new style of combat, with the development of

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

modern information technology, the future battlefield, weapons systems will become more and more complex, manned/unmanned combat will become the basic operational form of our special forces of the future, the study of its development and application is the key to win the future war. Become the future of our army special forces of the basic combat form, its development and use of research is the key to win the future war, countries around the world are now vigorously set up relevant professional detachments, empowering the relevant high-tech technology, in order to quickly develop manned / unmanned combat, seize the initiative on the battlefield.

2. RESEARCH DESIGN

2.1. Research methodology

By referring to the research of Sun Linhui et al. on "International Manned/Unmanned Aircraft Cooperative Operations Research Status, Hot Spots and Development Trends" by using the BiblioShiny visual analysis technique with the WoS data from 2000-2022 as a library[1] , we propose to use Citespace and Tableau data research and analysis software to explore the hidden information in the collected Cnki data in both qualitative and quantitative analysis. Tableau data research and analysis software is used to analyze the collected Cnki data qualitatively and quantitatively, and to explore the hidden information in the data.

Citespace is a tool for visualizing and analyzing the scientific literature network, which is characterized by its ability to show the interrelationships of authors and papers through graphics in a large number of related literature, as well as to show the themes, subfields, and major academic events of research in recent years through keyword analysis, clustering analysis, timeline analysis, and scientific research cooperation network analysis to provide a basis for researching the future development trend of the field. Tableau is a software with excellent visualization effect, which can transform complex data into intuitive and vivid visualization charts, such as bar charts, bar charts, line charts, maps, scatter plots and other forms, and supports custom chart styles, colors, fonts and so on, so that the user can personalize the design according to their own needs and preferences. Its visualization quality is high, with excellent performance in chart clarity, aesthetics and interactivity, which can help users better understand and convey data information. In addition to the basic data visualization functions, it also provides some advanced analysis functions, such as predictive analysis, cluster analysis, trend analysis, etc., to help users dig deeper into the potential patterns and trends in the data and provide strong support for decision-making.

2.2. Data acquisition

By logging into the China Knowledge Network and using advanced search to obtain relevant literature from the Cnki Academic Database, we set the search topic 1 "manned-unmanned, manned/unmanned, manned and unmanned, manned/unmanned" and the topic 2 "synergy, combat, synergy", in order to make the data collected more distinct and specific, we set the search topic relationship as "And", and the year as 2000-2024. In order to make the data collected more distinct and specific, we set the search subject relationship as "And", and the year limit as 2000-2024, mainly considering that the research on manned/unmanned system synergy has been developing rapidly in the last decade; a total of 295 pieces of literature were retrieved, combining with the scope of research and keywords to filter 283 pieces of literature (see the table below). keywords to screen the literature 283 (Table 1).

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

Table 1. Data statistical graph

Literature sources	Search Topics1	AndOr Not	Search Topics2	search term	Number of searches	Number of filters
Cnki	Manned-unmanned systems Manned/unmanned systems Manned and unmanned systems With/without manned systems	And	synergistic Service coordinated action	2000-2024	295	283

3. RESEARCH FINDINGS

Through the screening of all the literature information in a specific format imported into Citespace and Tableau software for data processing and analysis, in the use of Citespace data processing, set the same time nodes, node screening using g-index, set the K-value of 25, through the non-stop adjustments and validation, determined to take the Pathfinder pathfinding network algorithm, in order to make the data will not be too dispersed, to determine the overall pruning of the integrated network, after the completion of the setup, respectively, from the keywords, authors, institutions, as well as the level of the cited literature, cited authors for Tableau visualization research.

3.1. Analysis of the volume of communications

The research about manned/unmanned system cooperative warfare has started from a long time ago, only that with the progress of the times, the development of science and technology, the shape of the war changes, and the related research is more and more and more in-depth, especially in 2014, the related research began to show a spurt of growth (Fig. 1). The reason for this is that it is attributed to the international situation at that time, but also related to the rapid development of national science and technology, and more closely related to the security needs of the country.

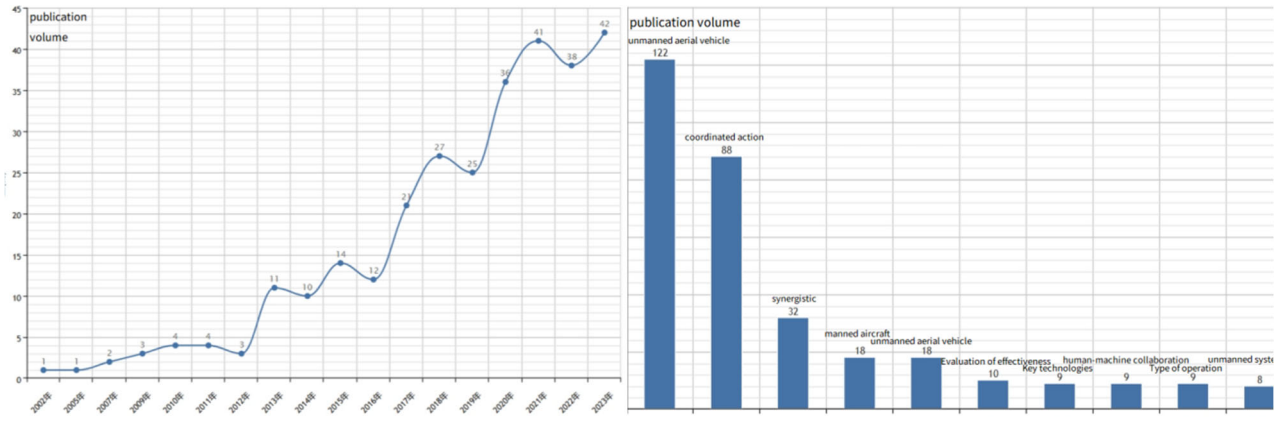

Figure 1. Data analysis graph

3.2. Keyword co-occurrence map

The CiteSpace keyword co-occurrence graph is important in a number of ways, one being that the node size of a keyword can reflect the frequency of the keyword's occurrence, and the higher the frequency of theIt indicates that it is a research hotspot in recent time; second, the change of the co-occurrence diagram under different time slices can understand the dynamic evolution process of the research hotspot; third, the connecting lines in the diagram indicate the covariance relationship with each other.By analyzing the keywords, a keyword co-

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

occurrence network containing 245 nodes and 342 connecting lines with a network density of 0.0114 wasformed, and through the adjustment of some graph parameters, the keyword co-occurrence network knowledge graph for domestic manned/unmanned system co-operation was obtained, as shown in Fig. 2.

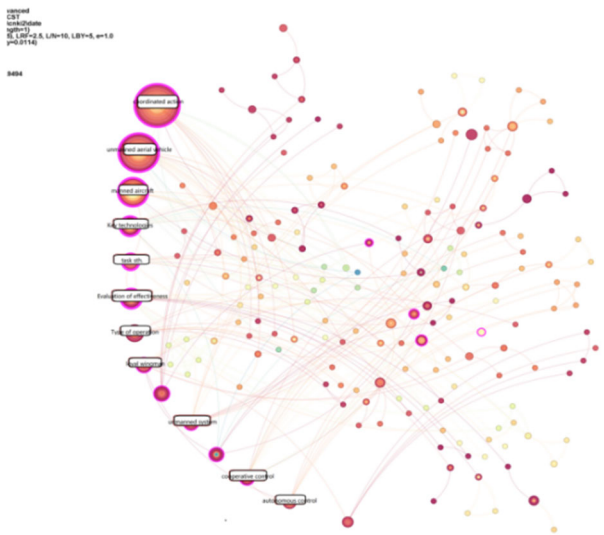

Figure 2. Keyword co-occurrence map

The closeness of a node to another node in the graph depends on its centrality, and when the centrality of a node is greater than 0.1, it is determined to be a key hub within the domain. High frequency and centrality indicate that the keyword centrality is important. From the data in Table 2, it can be seen that the keywords "UAV", "coordinated operations", "effectiveness evaluation", "coordinated control ", "operational planning" and "intelligent collaboration" are more important and play the role of bridge.

Table 2. Keyword co-occurrence sheet

byword	frequency	centrality	particular year
manned aircraft	24	0.38	2011
Key technologies	16	0.34	2009
coordinated action	76	0.33	2010
Evaluation of effectiveness	16	0.31	2013
task sth.	12	0.29	2013
unmanned aerial vehicle	67	0.21	2007
unmanned system	9	0.19	2016
command and control	12	0.18	2012
cooperative control	7	0.17	2014
air warfare	2	0.16	2014
loyal wingman	10	0.15	2017
intelligent collaboration	2	0.14	2019
artificial intelligence (AI)	9	0.13	2020
growing trend	6	0.11	2007
Type of operation	8	0.10	2019
synergistic	7	0.10	2014
autonomous control	2	0.10	2015

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

3.3. Keyword clustering mapping

CiteSpace keyword clustering diagram is to cluster a large number of keywords to show the thematic direction of the research field and the hierarchical relationship between the themes. The clarity of clustering is usually assessed using the values of Q and S (i.e., modular and mean contour values) in the graph.When the modular value (Q value) is greater than 0.3, it indicates that the clustering structure is significant; and when the mean contour value (S value) is greater than or equal to 0.7, it indicates that the clustering is reasonable and convincing . By analyzing the literature, a knowledge map of the keyword clustering network was obtained, as shown in Figure 5. In Figure 5, the connecting lines between the clustering modules indicate the degree of association between the keywords, and the denser the lines, the closer the association. The clustering knowledge map #0-#13 indicates that the domestic combat effectiveness assessment field is mainly centered on "manned aircraft", "effectiveness assessment", "command and control", "coordinated operation", "coordinated operation", "command and control" and "command and control". "Collaboration" "Loyal wingmen" "Unmanned systems" "Operational modes" "Tasking" and "Collaborative Decision Making".

Since it is difficult to obtain the specific information covered by the hotspot words through the cluster names, it is necessary to combine the analysis of subclusters to gain a deeper understanding of the specific content contained in each cluster name. Detailed information about the subclusters can be found in the table of hot word clustering for domestic manned/unmanned system cooperative combat research shown in Table 3, which will help to understand what the hot words represent more comprehensively. More specific and detailed domain-related information can be obtained by subclustering. For example, clustering collaborative warfare, it contains sub-clusters such as architecture, task assignment, collaborative decision making, system architecture, and task decomposition.

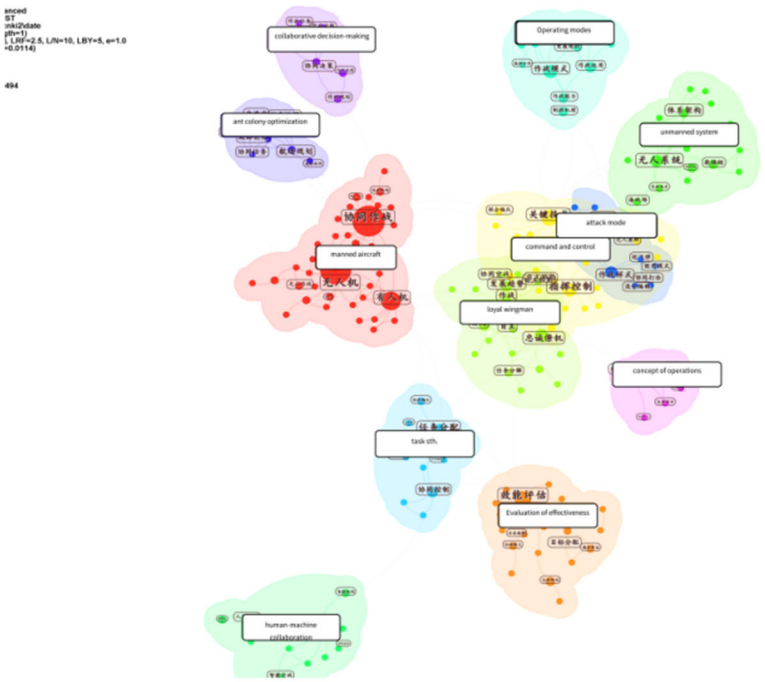

Figure 3. Keyword clustering mapping

3.4. Timeline mapping

CiteSpace timeline mapping can clearly delineate the development stages of a research field in different time intervals. By arranging the literature in chronological order on the timeline, it is possible to visualize the time periods in which the research activities are more active and the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

time periods in which they are relatively quiet, and each stage will show its unique characteristics; it is possible to see that "manned aircraft", "performance evaluation", "unmanned systems", etc. have been hot research topics for a period of time, and secondly, it is possible to trace the development of the research area. ""Unmanned systems" and the like have been a hot research topic for some time. Secondly, it is possible to trace the evolution of the research question and analyze the driving forces and influencing factors behind it. It can be seen that in the past decade, the research on "human-machine collaboration", "combat mode", "task allocation", "collaborative decision-making", "combat concept", etc. has gradually become a hot research topic. It can be seen that in the past decade, "human-machine collaboration", "combat mode", "task allocation", "collaborative decision-making", "combat concept" and so on have gradually become the main direction of research, reflecting the rapid development of contemporary science and technology; then it can also reflect the temporal correlation and interaction of different topics; finally, it can assist in predicting the trend of research, which can be predicted based on the historical trend, and also can discover the potential research direction.

Table 3. Timeline sheet

Serial number	Average year	contour value	Cluster name	Subcategory name
#0	2016	0.966	manned aircraft	Manned aircraft; Cooperative operations; Architecture; Hybrid formation
#1	2017	0.994	Evaluation of effectiveness	Performance assessment; target allocation; manned aircraft; man-machine coordination; manned aircraft/unmanned aircraft
#2	2016	0.873	command and control	Command and Control; Air Warfare; Key Technology; Cooperative Air Warfare; Autonomous
#3	2018	0.936	loyal wingman	Wingman; Loyal Wingman; Swarm; Mission Breakdown; Mission Assignment
#4	2018	0.924	unmanned system	Unmanned Systems; Data Chain; Architecture; Operations; System Confrontation
#5	2022	0.911	human-machine collaboration	Human-machine collaboration; Intelligent air warfare; Air warfare; Human-machine synergy; Human-machine mutual trust
#6	2020	0952	Operating modes	Operational Models; Current State of Development; Models; Operations; Wide Area Surveillance
#7	2016	0.978	task sth.	Task assignment; Cooperative control; Manned and unmanned detachments; Characterization of swarm relationships; Blackboard modeling
#8	2018	0.951	attack mode	Attack Mode; Combat Style; Mode; Weaponry; Coordinated Strike
#9	2013	0.989	ant colony optimization	Ant colony optimization; Distributed model predictive control; Suppression of enemy air defense systems; Mission coordination; Trajectory planning
#10	2019	1	collaborative decision-making	Collaborative Decision Making; Operations; Ship-Aircraft Collaboration; Operational Planning; Operational Processes
#13	2022	0.988	concept of operations	Operational Concepts;; System Design; Collaborative Architecture; Situational Synchronization; Technology Systems; Manned and Unmanned Distributed Collaborative Warfare

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

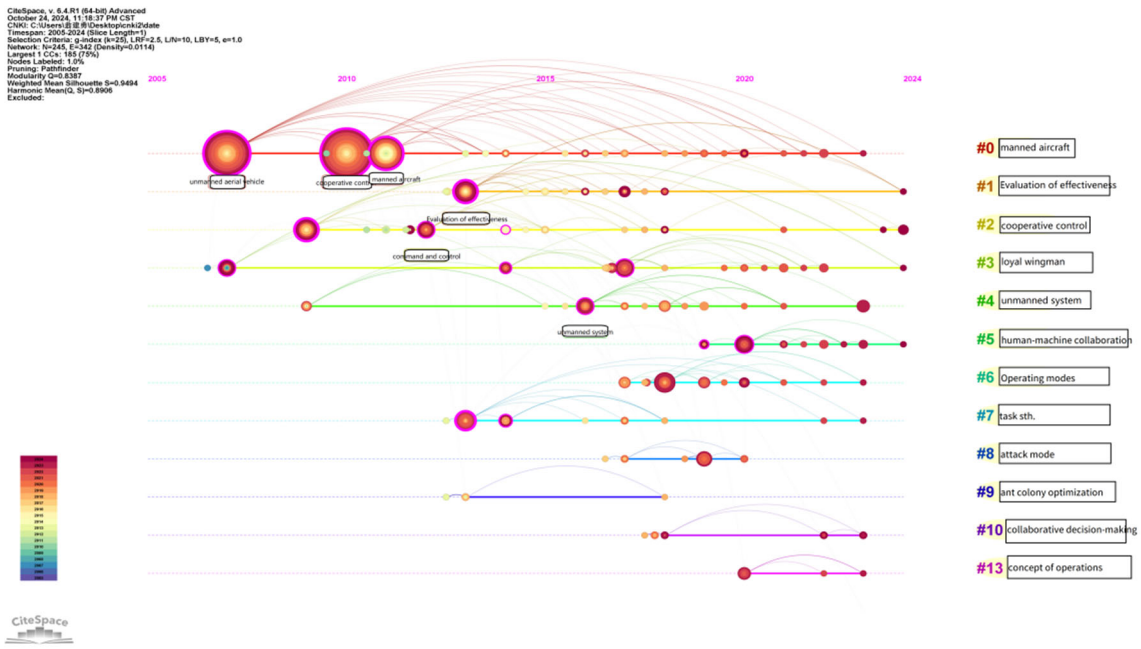

Figure 4. Timeline mapping

3.5. Keyword emergence mapping

CiteSpace Keyword Emergence Mapping provides a clear view of which topics suddenly become the focus of research at a given time, spotting emerging research frontiers and identifying turning points, in a timely manner.

According to the time of emergence (Figure 1) from top to bottom, it can clearly reflect that the hotspots of the current research are "cooperative control", "system architecture", "combat style", "combat application", "artificial intelligence" and "combat concept". "combat application", "artificial intelligence" and "combat concept"; sorted according to the intensity of emergence (Figure 2), the figure shows that over time, people's research focuses on It can be seen from the figure that as time goes by, the focus of research has gradually shifted from operational research such as manned aircraft, operational concepts, operational styles, and operational applications to technical research such as key technologies, cooperative control, and effectiveness evaluation, which on the one hand indicates that the focus of research is changing and the research of related theories has become more in-depth.

4. CONCLUSION

4.1. Construct a research system for manned/unmanned system synergistic operation

By analyzing and studying all the domestic literature related to the topic and summarizing the main contents of the research, we can roughly construct the research system of manned/unmanned system coordinated operation, which mainly includes the basic theory layer, mission layer and operation layer, and at the same time, each layer corresponds to the technical research consisting of models and algorithms, among which the content of basic theory research is mainly through borrowing from some foreign literatures and writings, and the mission management technology and operation technology are mainly learned from the domestic research on manned/unmanned system coordinated operation. The basic theory research is mainly based on some foreign literature and works, and the mission management technology and combat technology are mainly learned from the domestic research on manned aircraft/unmanned aircraft cooperative combat. It is found that there is no direct relationship between the research system and the order of research, the development of theories will promote the progress of technology, but conversely the progress of technology also improves

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

the related theories; the relationship between theories, missions, operations, and technologies is complementary and mutually reinforcing.

4.2. Sorting out research ideas for manned/unmanned system synergies

Manned/unmanned systems coordinated combat is an important development direction in the future, the United States, Russia, Britain, France and other military powers compete to invest a lot of manpower, energy, material and financial resources, especially the United States, its land, sea and air forces have developed their own manned/unmanned aircraft coordinated combat programs in conjunction with their own actual situation, which is very worthwhile for us to learn and learn from. Combined with the research ideas of general problems, referring to the domestic research methods on related problems since recent years, for the problem of manned/unmanned system coordinated combat, it is crucial to sort out the research ideas due to the fact that it involves more disciplines and specialties, which include both basic theoretical research and specialized technical needs, and also needs to be combined with specific combat for demonstration and improvement. At present, domestic research on airborne manned/unmanned cooperative warfare is more in-depth, but there are fewer studies on manned/unmanned cooperative warfare on the ground, at sea and in underwater space.

4.3. Identify key research directions for manned/unmanned systems co operation

By putting the two indicators of centrality and frequency of keywords into Tableau software for analysis and generating a tree diagram, the current main research directions in the field can be seen according to the depth of the color , in addition to the hotspots of the research about collaborative operations as well as unmanned aerial vehicles (UAVs), followed by the key technologies, task allocation and effectiveness evaluation, which correspond to the theoretical layer, the task layer and the operational layer, respectively. At present, at the technical level, the main solution to the problem of mission planning through modeling, through the study of grouping technology, cooperative control technology, command and control technology to map the combat technology, through the use of physical elements of topological evaluation method, gray hierarchical analysis, gray theory analysis, based on hopfield and other methods to assess the effectiveness of the combat, the above methods are very good solution to the current problem, but the development of science and technology is rapidly changing, and the battlefield environment is changing rapidly, and the battlefield environment is changing rapidly, and the battlefield environment is changing rapidly. However, with the rapid development of science and technology, the battlefield environment is changing rapidly, and more in-depth research is necessary to maximize the effectiveness of manned/unmanned systems in coordinated operations.

REFERENCES

[1] SUN Linhui,LI Xun. Research status, hotspots and development trend of international manned/unmanned aircraft coordinated combat - BiblioShiny visualization and analysis based on WoS data from 2000-2022[J]. Sino-Arab Science and Technology Forum (in Chinese and English), 2023, (05):48-58.

[2] WU Qiwu, LIU Jiaqi, WU Husheng. Analysis of research hotspots and development trend of unmanned aerial vehicle (UAV) cluster mission planning [J]. Journal of Weapons and Equipment Engineering, 2023, 44(5): 294-302.

[3] Zhang Honghong, Li Wenhua, Zheng Jiayi, et al. Manned/unmanned aircraft cooperative operations: concepts, technologies and challenges [J]. Journal of Aeronautics, 2024, 45(15):029653.

[4] JIANG Peng, WANG Rui, ZHENG Lihui, et al. Research status and development trend of foreign manned/unmanned aircraft cooperative warfare[J]. Military Automation,2023,42(03):84-89.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

[5] ZHANG Lu, DANG Jing, SHAO Zhengtu. Analysis and revelation of Russian army's manned aircraft and unmanned aircraft cooperative warfare[J]. Ship Electronic Countermeasures,2022,45(03):1-6.DOI:10.16426/j.cnki.jcdzdk.2022.03.001.

[6] ZHANG Lu, SHAO Zhengtu, WENG Chengxiang, et al. Research on the utilization and key technology of U.S. Army's have/UAV cooperative operation[J]. Tactical Missile Technology, 2022, (06): 128-137.DOI:10.16358/j.issn.1009-1300.20220021.

[7] LI Song, ZHANG Chunhua, SUN Yufei, et al. Study on the Development of Cross-domain Cooperative Warfare Capability of U.S. Army Unmanned Systems[J]. China Academy of Electronic Science and Technology

[8] li wen,chen jian. Research review and outlook of manned aircraft/unmanned aircraft hybrid formation cooperative operation [J]. Aerospace Control, 2017, 35 (03): 90-96. DOI:10.16804/j.cnki.issn1006-3242.2017.03.017.

[9] Chen Lingsong, Ji Simei, Guo Mei. Research on task allocation method of have/UAV cooperative operation[J]. Flying Missile 2015.(07):36-38.DOI:10.16338/j.issn.1009-1319.2015.07.08.

[10] Zhang Xinwei. A hybrid manned/unmanned aircraft formation cooperative task allocation method[J]. Modern Navigation,2017,8(06):417-421.

[11] ZHOU Wei-Qiang,SU Yao. Design and research of interoperability model for manned/unmanned aircraft cooperative operations[C]//China Command and Control Society. Proceedings of the Ninth China Command and Control Conference. Communication Branch, 20th Research Institute of China Electronics Technology Group Corporation;,2021:6.DOI:10.26914/c.cnkihy.2021.011206.

[12] Hu Yue. Research on manned/unmanned aircraft cooperative combat task allocation and trajectory planning [D]. Nanjing University of Aeronautics and Astronautics, 2020.DOI:10.27239/d.cnki.gnhhu.2020.000168.

[13] LIU Hongqiang, WEI Xianzhi, FU Zhaowang, et al. Research on task allocation method of manned aircraft/unmanned aircraft formation coordinated attack [J]. Electro-Optics and Control, 2013, 20(06): 16-19.

[14] T.D. Chen. Research on key technology of combat mission planning for manned/unmanned detachment [D]. Nanjing University of Science and Technology, 2023.DOI:10.27241/d.cnki.gnjgu.2023.000028.

[15] ZHAO Tuo,ZHANG Xianjian,HUANG Jian. Manned/unmanned aircraft cooperative air combat mission planning technology[J]. Firepower and Command and Control,2024,49(02):1-10.

[16] ZHANG Jia,LIU Qingping,XIN Bin. Research on mission understanding of manned/unmanned system cooperative operation[J]. Firepower and Command and Control,2022,47(10):52-58.

[17] ZHAO Xiaoru, YANG Renong, YAN Mengda, et al. Modeling of manned-unmanned cooperative combat architecture based on combat management[J]. Air Force Engineering University

[18] DING Lianghui,TIAN Jiaming,ZHANG Yate,et al. Design of manned/unmanned cooperative amphibious landing combat architecture based on DoDAF[C]//Chinese Command and Control Society.2023 Proceedings of the Seventh National Conference on Cluster Intelligence and Cooperative Control. Shanghai Jiao Tong University;China Aviation Radio Electronics Research Institute;Shanghai Institute of Electromechanical Engineering;, 2023:8.DOI:10.26914/c.cnkihy.2023.120073.

[19] JANG Yucheng,GUO Kilian. Design of manned aircraft/unmanned aircraft cooperative effect evaluation model[J]. Military Operations and Systems Engineering,2016,30(03):28-31.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

[20] SHI FENGCHA, BAI JIANGBO, LU Di. Analysis of foreign army with/without manned grouping technology[J]. Command Control and Simulation,2024,46(01):30-36.

[21] Huang Songhua. Key Technology Analysis of Manned/Unmanned Distributed Combat System[C]//China Command and Control Society. Proceedings of the Sixth China Command and Control Conference (Previous Volume). Key Laboratory of Information System Engineering;,2018:5.

[22] Jieyong Zhang, Eddie Zhong, Peng Sun, Jinzhe Ma. Manned/unmanned aircraft cooperative operation command and control system technology [J]. Journal of Command and Control, 2021, 7(2): 203-214

[23] WANG Xun,YAO Peiyang,TAI Dongdong. On manned aircraft/unmanned aircraft formation cooperative combat decision making[J]. Computer Simulation,2015,32(09):128-132.

[24] Jun Chen, Xinwei Zhang, Jia Xu, et al. Finite-intervention cooperative decision-making for manned/unmanned aircraft hybrid formation [J]. Journal of Aviation, 2015, 36(11):365236- 65.

[25] Yang Yulong. Research on manned aircraft/unmanned aircraft cooperative operation mode and key technology[C]// China Aviation Society. Proceedings of the Fifth China Aviation Science and Technology Conference. China Aviation Radio Electronics Research.

[26] SHI Guoqing,WU Fan,ZHANG Lin,et al. Analysis of manned/unmanned aircraft cooperative combat capability based on combined empowerment method[J]. Firepower and Command and Control,2019,44(04):87-91.

[27] Bao Zhan, Wang Shuwen. Research on the generation problem of manned/unmanned aircraft cooperative combat capability[J]. National Defense Science and Technology,2017,38(03):76-79.DOI:10.13943/j.issn1671-4547.2017.03.12.

[28] HUANG Songhua,ZHANG Zhaochen. Research on the Development of Manned/Unmanned Distributed Combat System of U.S. Army[C]// China Command and Control Society. Proceedings of the Sixth China Command and Control Conference (Previous Volume). Key Laboratory of Information System Engineering;,2018:5.

[29] ZHANG Yongli,SUN Zhishui,ZHOU Rongkun. Evaluation of manned aircraft/unmanned aircraft cooperative combat effectiveness based on AHP-fuzzy comprehensive judgment method[J]. Ship Electronic Countermeasures,2015,38(06):80-84+92.DOI:10.16426/j.cnki.jcdzdk.2015.06.019.

[30] WANG Tan, YANG Sen, QI Xiaohui, et al. Evaluation of manned aircraft/unmanned aircraft cooperative combat effectiveness based on Hopfield network[J]. Electro-Optics and Control,2021,28(10):80-84.

[31] MA Jiufang,YANG Sen,HUANG Xinxin. Evaluation of manned/unmanned cooperative combat effectiveness based on gray hierarchical analysis[J]. Telecommunications Technology, 2023, 63 (10): 1625-1630.DOI:10.20079/j.issn.1001-893x.230428001.

[32] HAN Yueming,LIU Tielin,XUE Hui. Evaluation of manned/unmanned aircraft cooperative combat effectiveness based on gray theory[J]. Military Operations Research and Evaluation, 2023, 38(01): 20-26.DOI:10.19949/j.ams.mora.20220711.01.

[33] WANG Guangyuan, SUN Tao, MAO Shichao, et al. Research on the assessment of operational effectiveness of manned aircraft/unmanned aircraft attacking the sea based on mission synergy[J]. Journal of Naval Aviation Engineering Institute,2017,32(05):491-495.

[34] LI Qi, WEI Xiaolong, LI Shenghou, et al. Object-element topological evaluation of manned aircraft/unmanned aircraft cooperative combat effectiveness[J]. Firepower and Command and Control,2024,49(05):9-17.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0007

[35] ZHANG Wenbo,LI Xiaojun,LIU Bin. There are/UAV collaborative combat development status and combat utilization exploration[J]. Flying and navigation guide

[36] DING Dali, XIE Lei, WANG Yuan. Manned aircraft/unmanned aircraft cooperative combat utilization and impact on war patterns [J]. Unmanned Systems Technology, 2020, 3(04): 1-9.DOI:10.19942/j.issn.2096-5915.2020.04.001.

[37] WANG Qi, FENG Wei-Qiang, KONG Wei-Wei, et al. A preliminary study on cooperative control of surface manned/unmanned ships[J]. Ship Science and Technology,2024,46(17):127-131.

[38] SUN Shengzhi, SHENG Biqi, ZHANG Yuqiang, et al. Underwater cooperative operation mode and key technology[J]. Journal of Weapons and Equipment Engineering,2024,45(08):274-279.

[39] KOU Kunhu, WANG Yaping, SHANG Zaifei. Research on command and control system and cooperative mode of UAV for sea combat[J]. Firepower and Command and Control,2024,49(06):68-74.

[40] ZHAO Zhen, LIU Wenjun, LAN Xiaoping, et al. Research on rapid assessment method of combat effectiveness of manned/unmanned equipment system[J]. New Technology and New Process, 2024, (03): 39-43.DOI:10.16635/j.cnki.1003-5311.2024.03.006.

[41] Ning M ,Yunfeng C .Consensus-based distributed formation control for coordinated battle system of manned/unmanned aerial vehicles[J]. Transactions of the Institute of Measurement and Control, 2024, 46(1):3-14.

[42] Shulan Y ,Zhiwei H ,Hongbo C .Evaluation of vulnerability of MAV/UAV collaborative combat network based on complex network[J].Chaos, Solitons and Fractals: the interdisciplinary journal of Nonlinear Science, and Nonequilibrium and Complex Phenomena,2023,172

[43] HU Xueshun,ZENG Jinshu. Research on the development and utilization of manned/unmanned cooperative combat[C]//Chinese Institute of Command and Control (CICC). Proceedings of the 11th China Command and Control Conference. College of Information and Communication, National University of Defense Technology;,2023:4.DOI:10.26914/c.cnkihy.2023.043591.

[44] YE Kunwu,NIU Chao, LIU Zehua,et al. Human-machine relationship in intelligent air warfare [C]//Chinese Institute of Command and Control (CICC). Proceedings of the 11th China Command and Control Conference. Chinese People's Liberation Army Unit 93210; Beijing Institute of Technology;, 2023:6.DOI:10.26914/c.cnkihy.2023.043569.

[45] Intervention decision-making in MAV/UAV cooperative engagement based on human factors engineering[J].Journal of Systems Engineering and Electronics,2018,29(3):530-530.

[46] Liang X ,Xuanhong P ,Ming W .Analysis on manned/unmanned aerial vehicle cooperative operation in antisubmarine warfare[J].Zhongguo Jianchuan Yanjiu,2018,13(6):154-159.