

# Development Status and Project Interpretation of the Robotics Wushu Competition

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**Abstract:** The Robotics Wushu Competition is a robotics competition that integrates intelligent robotics technology with traditional Chinese Wushu culture, maker spirit, and ideas. It is a highly confrontational and ornamental project in robotics competitions. This paper discusses the current situation, development status, and project settings of the Robotics Wushu Competition in the three major national competitions, focusing on the interpretation of several major projects, such as humanoid autonomous fighting, body-feeling humanoid fighting, wheeled autonomous fighting, visual confrontation, and unmanned aerial vehicle (UAV) confrontation. Finally, suggestions are proposed to support the regular holding and development of the Robotics Wushu Competition.

**Keywords:** Robotics Wushu Competition; Autonomous fighting; Humanoid fighting; Visual confrontation; UAV confrontation

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## 1. Introduction

On March 22, 2022, the College Competition Evaluation and Management System Research Working Group of the Chinese Higher Education Association released the 2021 National College Competition Ranking <sup>[1]</sup>. A total of 56 competitions were included in the 2017–2021 competition ranking list. These 56 competitions have been officially recognized by the Ministry of Education, with the most gold content and the highest competitive value. Among them, there are five competitions with the theme of “robotics,” and nearly 10 competitions that are related to it. Robotics competition plays a significant role in the academic competition of colleges and universities in China.

The Robotics Wushu Competition is a highly confrontational and ornamental project in robotics competitions. Its aim is to promote the popularization of intelligent robotics, especially the application and development of autonomous identification and decision-making technology. Within limits permitted by the rules, each participating team sends a self-assembled or self-made autonomous robot to fight against each other to win the competition. The Robotics Wushu Competition promotes the popularization and development of robotics technology in the form of confrontational competition among students and teenagers <sup>[2-4]</sup>.

## 2. Overview of the Robotics Wushu Competition

The Robotics Wushu Competition is a robotics competition that integrates intelligent robotics technology with traditional Chinese Wushu culture, maker spirit, and ideas. It is one of the earliest competitions among all kinds of robotics competitions in China to achieve success or failure through autonomous robot

confrontation. The participating teams would design and manufacture autonomous robots that use various sensors to detect their own position and that of their opponents in the arena, change their strategies from offensive to defensive and vice versa according to the programmed algorithm, as well as use various actuators (weapons) to attack their opponents and push their opponents out from the arena to win. Other than being highly valued by students, the competition fully exploits their practical ability, innovation ability, and teamwork ability as it can be integrated with mainstream robotics technology and has a high level of openness, confrontation, interest, and ornamental value.

The Robotics Wushu Competition is based on the confrontational, technical, and interactive characteristics of the Wushu spirit, combined with the development of robotics technology, mainly through the sub-game content and rules set, and it reflects the application and promotion of robotics from several aspects.

#### (1) Athletic ability

Wushu is to stimulate the potential of the all-round movement of the human body. From the perspective of robotics platform, robots are developing from wheeled platform to bionic platform and from single-arm confrontation to both, arms and feet confrontation.

#### (2) Positioning and perception

The arena elements such as Baguazhang and Meihuazhuang have distinct cultural connotations. On the one hand, the design of the Wushu arena should reflect the cultural connotation; on the other hand, it provides a stage for the endless application of robotics positioning and environmental perception technology. The event settings can be developed from a simple content such as edge detection and staging landing, to advanced technologies such as ultra-wideband (UWB) positioning and visual simultaneous localization and mapping (vSLAM). At the same time, the confrontation characteristics of Wushu require high processing speed, thus posing extreme challenges to various vision-based algorithms.

#### (3) Human-machine cooperation

The highest level of Wushu is to be proficient in all eighteen weapons. The use of weapons is an important part of Wushu culture. In Wushu competitions, the confrontation of robots is the embodiment of human confrontation. Therefore, robotics technologies including human-machine interaction and human-in-the-loop are actively used in competitions, highlighting the role of the subjective factors of human beings in confrontation, so as to improve the ornamental value, competitive degree, and excitement of competitions.

#### (4) Group control

From the very beginning, Wushu is the paradigm of heterogeneous multi-body collaboration. From different methods to the application of various weapons, they embody the wisdom of the Chinese people. Therefore, with the development of robotics technology, heterogeneous robot identification, coordination, and confrontation decision-making technologies are the main development directions of Wushu competitions in the future.

The ultimate goal of the Robotics Wushu Competition is to enable humanoid robots to perform Wushu fighting movements akin to those seen in Chinese Wushu competitions, gain athletic ability in the arena, the perception of the arena, and the ability to hit precisely with hand-eye coordination, recognize friends from foes, as well as develop situational awareness of the opponent's ability. The combat level of human Wushu competition is finally achieved by complex movements, sensitive and accurate environmental perception, as well as high-speed dynamic planning and decision-making.

### **3. Development status of the Robotics Wushu Competition**

At present, there are three national robotics competitions based on the Robotics Wushu Competition project.

### 3.1. China Robot Competition

China Robot Competition is the largest and most influential robotics competition in China, which is co-sponsored by the Chinese Automation Society and the College Automation Teaching Committee of the Ministry of Education. As one of the oldest robot competitions in China, this competition has been held for 23 times from 1999 to 2021 [5].

The Robotics Wushu Competition first appeared on the stage of China Robot Competition in 2008, which has a history of 14 years. The 2021 China Robot Competition has two levels of competition: special competition and final competition. The Robotics Wushu Special Competition has three sub-games: humanoid autonomous fighting, body-feeling humanoid fighting, and visual confrontation. On the other hand, the final competition has 2 sub-games: human-machine cooperative attack and defense competition and visual confrontation. From July 30, 2021, to August 1, 2021, the Robotics Wushu Special Competition was held in Luoyang Institute of Technology. This competition attracted a total of 131 teams from 63 schools nationwide. A total of 53 teams were selected to participate in the final competition. **Table 1** lists the participation of the Robotics Wushu Special Competition.

**Table 1.** 2021 Robotics Wushu Special Competition participation

Project	Number of teams	Number of schools	Number of players	Number of teams advancing to the finals
Humanoid autonomous fighting	58	44	202	35
Body-feeling humanoid fighting	47	33	177	18
Visual confrontation	26	19	102	53
All	131	63	454	

### 3.2. China University Intelligent Robot Creative Competition

China University Intelligent Robot Creative Competition is a nationwide academic competition with widespread influence. In 2017, the first China University Intelligent Robot Creative Competition was co-sponsored by the China Higher Education Society, the Engineering Graphics Course Teaching Steering Committee of the Ministry of Education, and the China University Intelligent Robot Creative Competition Organizing Committee. The Robot Research Institute of Zhejiang University and the Engineering Education Committee of the Institute of Higher Education of China are the organizers, and the competition is held annually. Taking “Better, Faster and Stronger” as its theme, the competition not only cultivates students’ ability to ask questions, but also their ability to solve problems. Colleges and universities participate in the competition with high enthusiasm and wide participation. It is a well-known intelligent robotics competition in China [6].

In 2021, the 4th China University Intelligent Robot Creative Competition had three theme competitions and an invitational competition. The third theme “Creative Fighting – Intelligent Robot Fighting Competition (IRFC)” is much more challenging and is divided into two categories: the unified component group and the open component group.

### 3.3. China Intelligent Robot Fighting and Competitive Competition

China Intelligent Robot Fighting and Competitive Competition was developed based on the Robotics Wushu Competition. It has been held yearly for 14 years since 2008. In recent years, there is an average of more than 200 universities and 800 teams enrolled each year. The competition is divided into two stages: preliminary selection and the finals. The competition has promoted the spread of the maker spirit, which includes innovation, practice, cooperation, and sharing; accelerated the popularization and development of

AI and robotics among young people; as well as cultivated and selected a number of excellent innovative new technology talents. It has received extensive attention and support from all walks of life, including the government, various industries, research, and academia, garnering great industrial and social influence [7]. The 2021 China Intelligent Robot Fighting and Competitive Competition held online at Beijing University of Technology had 12 projects [8], including wheeled/humanoid autonomous fighting, body-feeling humanoid fighting, robot visual confrontation, and intelligent UAV confrontation. A total of 602 participating teams underwent three stages: preliminary selection, finals, and online live broadcast. In the end, 263 teams were awarded, of which 52 won first-place prizes, 89 won second-place prizes, and 122 won third-place prizes.

#### 4. Main projects of the Robotics Wushu Competition

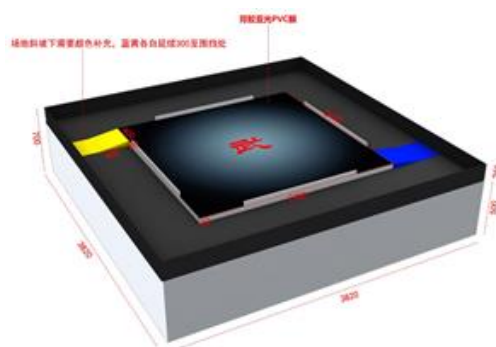
Table 2 is a list of the main projects of the Robotics Wushu Competition in the three national robot competitions in 2021.

**Table 2.** List of the Robotics Wushu Competition main projects

Robotics Wushu Competition main projects	China Robot Competition	China University Intelligent Robot Creative Competition	China Intelligent Robot Fighting and Competitive Competition
Humanoid autonomous fighting	•		•
Body-feeling humanoid fighting	•	•	•
Human-machine cooperative attack and defense competition	•		
Visual confrontation	•	•	•
Wheeled autonomous fighting		•	•
UAV confrontation	•	•	•
Smart car challenge	•		

##### 4.1. Humanoid autonomous fighting

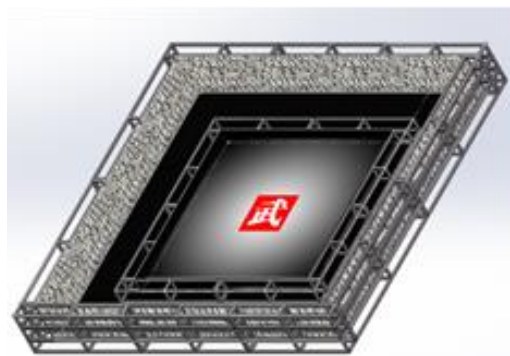
Humanoid autonomous fighting is a confrontational robot competition. The participating robots must be autonomous. The body parts must have several basic human characteristics, such as head, torso, limbs, and two arms, with each arm having not less than three dynamic joints. Each game lasts for two minutes. Once the game begins, the robot needs to climb up the 6-centimeter-high competition field from the slope, look for the opponent, and knock the opponent down or push the opponent off the arena autonomously. During this process, if the robot falls, it should be able to stand on its own and continue the game; if the robot is pushed off the arena, it should be able to climb up the slope from the starting point again. After the game is over, the team with the most points wins [9]. The humanoid autonomous fighting arena is shown in **Figure 1**.



**Figure 1.** Humanoid autonomous fighting arena

#### 4.2. Body-feeling humanoid fighting

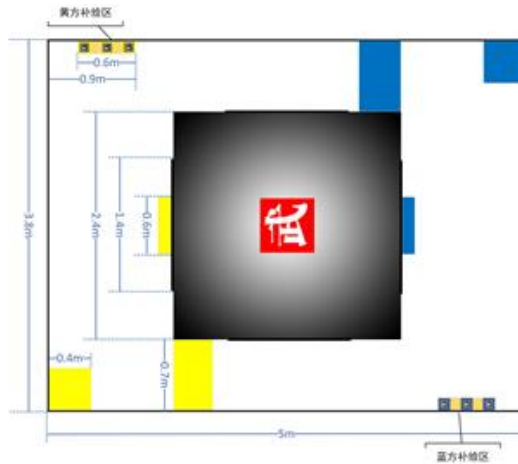
Body-feeling humanoid fighting requires the robot to be a semi-humanoid robot. The robot must have two arms and an omnidirectional mobile chassis. Only one arm can be equipped with fighting weapons, but both arms may make martial arts movements under the control of the somatosensory system. One person uses the somatosensory system to control the robot to perform martial arts movements, while the other controls the start and stop of the robot. By precisely striking the opponent's key parts, the opponent's HP may be exhausted. Once it is exhausted or whoever has more HP left at the end of the game wins. During the competition, the robot is required to complete a number of tasks within a specified time. Each task has a corresponding score. Beginning from the starting point, the robot will complete the tasks in sequence and finally attempt to engage in combat in the arena. The greater the number of tasks completed and the less time it takes, the higher the score. The score obtained from clearing the tasks affects the initial HP in the final fight <sup>[10]</sup>. The arena is shown in **Figure 2**.



**Figure 2.** Body-feeling humanoid fighting arena

#### 4.3. Human-machine cooperative attack and defense competition

Human-machine cooperative attack and defense competition is the finals of humanoid autonomous fighting and body-feeling humanoid fighting. The 2021 human-machine cooperative attack and defense competition absorbed the technical features of humanoid autonomous fighting and body-feeling humanoid fighting as well as added visual processing content. In addition to normal arena fighting and body-feeling handling, the participating robots must distinguish the energy blocks in the arena, which increases the technical difficulty of the game. Each team needs to prepare two robots to complete body-feeling handling and autonomous fighting, respectively. There are energy blocks arranged around the arena; the body-feeling robot needs to transport the energy blocks from its own supply area to its own arena shelves, whereas the autonomous robot needs to climb up the 6-centimeter-high competition field from the slope, look for the opponent, and knock the opponent down or push it off the arena. During this process, if the robot falls, it should be able to stand on its own and continue the game. If it is pushed off the arena, it should be able to climb up the slope from the starting point again. Another rule is that the autonomous robot can push down the opponent's energy block in the arena <sup>[11]</sup>. The arena is shown in **Figure 3**.

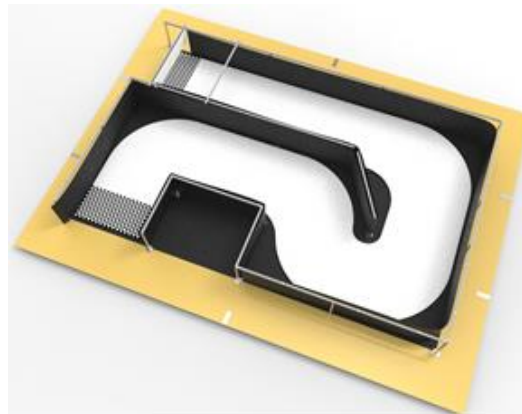


**Figure 3.** Human-machine cooperative attack and defense competition arena

#### 4.4. Visual confrontation

##### 4.4.1. Visual confrontation A

Visual confrontation A gradually improves the application level of machine vision and motion control in robot fighting confrontation by setting tasks of different levels of difficulty. The robot walks to the target area autonomously through visual recognition of the road and completes the task of hitting the target. The robot begins from the starting point, recognizes the road visually, advances to the target area along the road, and then completes the attack on the target. The best result is achieved within a limited time. The competition consists of two rounds, and the participating teams decide the order of the competition by drawing lots prior to the competition. The total score is given on the spot for each round. The average of the two rounds is taken for the final ranking. If the results are the same, the team that completed the task within a shorter time will be ranked higher <sup>[12]</sup>. The venue is shown in **Figure 4**.



**Figure 4.** Visual confrontation A venue

##### 4.4.2. Visual confrontation B

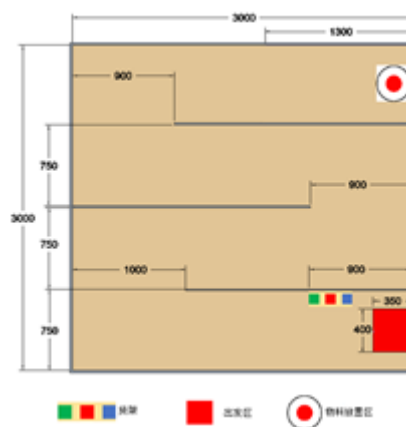
Visual confrontation B is a task-based event. The participating robots need to complete specific tasks quickly and accurately within a specified time. Autonomously, the robot finds and recognizes the balloon that simulates the target in a given field and punctures the target balloon or leaves marks on the target portrait with a pen. The robot is required to complete the field tasks within a specified time. The points will be converted into scores based on the completion time. The addition and deduction items are calculated based on the performance of the robot in the competition, and the total score will reflect the result of the competition <sup>[13]</sup>. The venue is shown in **Figure 5**.



**Figure 5.** Visual confrontation B venue

#### 4.4.3. Visual confrontation C

Visual confrontation C simulates the future intelligent production workshop. The intelligent robot completes the material transportation task according to the demand, and vision is used to guide the robot's arm to grab the goods. After grabbing the correct goods, the robot needs to carry the goods on the track that simulates the factory workshop channel, move and avoid obstacles, complete the placement of the cargo after reaching the cargo placement area, and then return to the starting point to complete the transportation of the second cargo until all the cargos are transported. The performance of each team is evaluated based on the time when the robot completes the task, the accuracy of the goods grabbed and placed, the obstacle avoidance effect, and other components <sup>[14]</sup>. The venue is shown in **Figure 6**.



**Figure 6.** Visual confrontation C venue

#### 4.5. Wheeled autonomous fighting

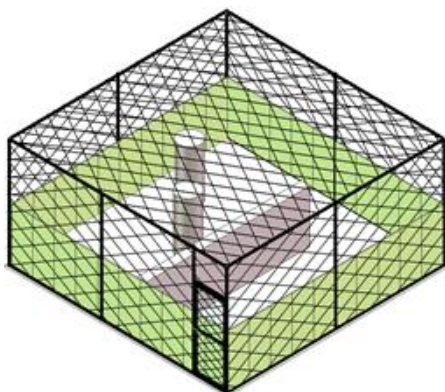
Wheeled autonomous fighting is an adversarial robot competition similar to human competition. Two self-made robots use different control methods to find the opponent in a square arena and use the weapons allowed by the rules to attack each other, in order to achieve the purpose of knocking down the opponent or laying down the arena. During the competition, the robot needs to use various sensors to perceive its own position as well as the opponent's position and direction, in order to push the opponent down to obtain scores. Each round is 2 minutes long, and after the game is over, the team with the most points wins. The schedule is divided into group stage and knockout stage. The visual processing content is added in the 2021 wheeled autonomous fighting competition. In addition to normal arena fighting, the participating robots must also distinguish the energy blocks in the arena, which increases the technical difficulty of the competition. The robot in the unified component group must use unified standard controllers, sensors,

weapons, and other components. The participating robots in the open component group must meet the size and weight requirements specified in the rules, but the materials are not limited <sup>[15]</sup>. The venue is the same as shown in **Figure 1**.

#### 4.6. UAV confrontation

##### 4.6.1. UAV confrontation A

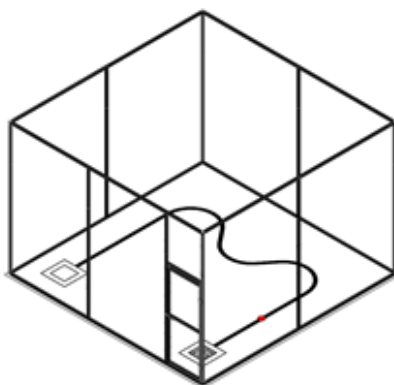
UAV confrontation A is a mission-based competition. After taking off from the take-off area, the UAV plans the path independently and enters an unfamiliar environment. It passes through a door and finally reaches the target point. Before reaching the target point, a picture is placed at the designated position of the target point. The picture content is divided into ten categories, in which one is posted from ten object categories. The UAV needs to identify the posted picture and print the picture and the object category in the picture on the terminal. The UAV must land autonomously to complete the task without any intervention by remote control. According to the flight status and recognition effect of the UAV, scores are given <sup>[16]</sup>. The field is shown in **Figure 7**.



**Figure 7.** UAV confrontation A field

##### 4.6.2. UAV confrontation B

UAV confrontation B is a mission-based competition. After the UAV takes off from the take-off area, it moves along the black line. The UAV needs to successfully trigger the sensors on the path and finally reach the stop area. A QR code is pasted in the center of the stop area. The UAV needs to recognize the QR code information, adjust the landing attitude independently, and successfully land in the stop area to complete the task. No intervention by remote control is allowed during the process. The scoring is based on the flight state and recognition effect of the UAV <sup>[17]</sup>. A sketch map of UAV confrontation B is shown in **Figure 8**.

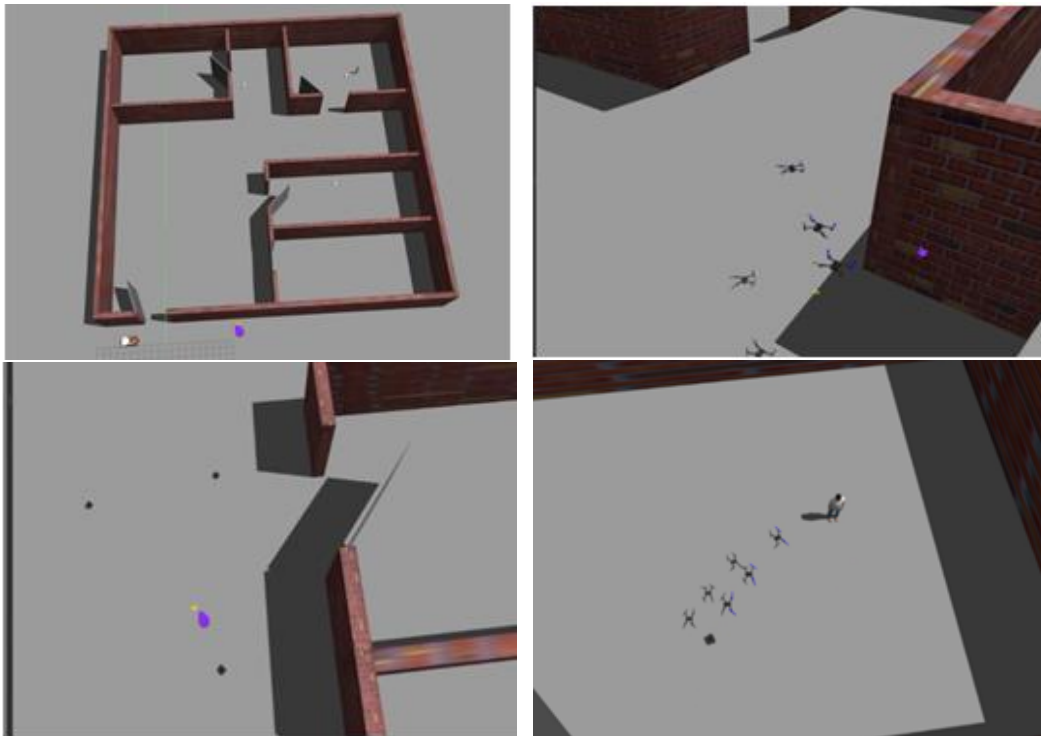


**Figure 8.** Sketch map of UAV confrontation B



### 4.6.3. UAV confrontation C

UAV confrontation C is a simulation project to simulate the scenario of land-air cooperative anti-terrorism exercises. This project reduces the degree of hardware dependence and highlights the role of ground and aerial stereoscopic heterogeneous clusters in real scenarios. Teams are required to use ground cluster robots to complete the search and positioning of “terrorists” in a unified simulation scene and use air cluster UAVs to complete the strike on these “terrorists.” According to the completion time and effect, the results of each participating team will be evaluated comprehensively <sup>[18]</sup>. An example of the simulation scene is shown in **Figure 9**.



**Figure 9.** UAV confrontation C simulation scene

## 5. Conclusion

The Robotics Wushu Competition integrates intelligent robotics technology with traditional Chinese Wushu culture. While promoting the development of intelligent robotics, it also promotes traditional Chinese culture. In the new era, it carries positive significance. Moreover, the competition is highly confrontational, ornamental, and exciting. Therefore, it is foreseeable that its’ popularity will grow, and it will continue to develop in the future.

In recent years, major national competitions have adopted the two-stage competition system, comprising of the preliminary round and the finals, to improve the quality of competitions. If offline competitions are carried out, the burden on participating schools and students will become heavier with the increase in human and material resources. Moreover, the growth of offline competitions has been restricted due to the normalization of COVID-19 prevention and control in recent years. Therefore, it is necessary to improve and innovate the existing forms and rules of the Robotics Wushu Competition, such as the hybrid scheme of online preliminary competition and offline finals, so as to ensure the regular holding and smooth development of the Robotics Wushu Competition.

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## Disclosure statement

The authors declare no conflict of interest.

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