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Research and Practice on the Cultivation Mode of Innovative Practical Ability of Computer Science and Technology Undergraduates through RoboMaster Match as a Carrier

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Abstract: In the current higher education system, the cultivation of undergraduate students' innovation ability has become the focus of teaching reform. This study aims to explore the undergraduate innovation ability cultivation mode with RoboMaster Mecha Master Match as the carrier, and verify its effectiveness in practice. Through literature review and case analysis, this paper constructs an innovative teaching mode that combines theoretical learning and practical operation, which emphasizes the integration of interdisciplinary knowledge, teamwork and the cultivation of problem-solving ability, and cultivates comprehensive talents with innovative ability and innovative spirit.

Keywords: RoboMaster MechMaster; Creative Ability; Interdisciplinary; Practical Teaching.

1. Introduction

In today's fast-changing era, innovation is not only the engine of economic development, but also the key to social progress. The challenges and opportunities brought about by globalization and technological change have raised the requirements for comprehensive ability and innovative thinking of engineering talents. Under such a background, higher education takes the responsibility of cultivating compound talents with innovative spirit and practical skills. The exploration of effective educational models to stimulate students' potential for innovation and improve their ability to solve practical problems has become an urgent task [1].

RoboMaster Mecha Master Match is a platform born out of this demand. As an important event of the National University Robotics Competition, it not only provides a stage for global science and technology enthusiasts to show their technology and exchange academic knowledge, but also opens up an ideal innovation and practice platform for undergraduates through the robotic battles that combine technical challenges, teamwork and competitive fun. The tournament covers a variety of technical fields such as machine vision, embedded system design, mechanical control, autonomous navigation, human-machine interaction, etc. It also includes the test of soft skills such as strategic planning and team management, and all these elements work together to make RoboMaster become an effective way to enhance students' innovation and engineering practice ability.

2. Current Research Status of Cultivation of Innovative Practical Ability of Students in Colleges and Universities

Under the background of innovation-driven development strategy, the cultivation of innovation and practice ability of undergraduates has become the core expectation and requirement of undergraduate education construction. At present, domestic colleges and universities have carried out a lot of research and exploration on the cultivation of undergraduate innovation and practice ability [2], and have formed diversified and regionalized cultivation modes and teaching methods. They mainly include the following aspects:

Reconstructing the curriculum system: adjusting the talent training program to ensure that the content and structure of the curriculum are better adapted to the development needs of the times, and to enhance students' practical skills and innovation ability.

Integration of practical teaching of course clusters: closely integrating theory and practice, promoting the use of diversified practical teaching methods and tools, such as project-based learning and case study.

Comprehensive internationalized teaching system: To build an internationalized teaching system and provide students with a learning environment with an international perspective.

Joint engineering practice bases of schools and enterprises: cooperating with enterprises to establish engineering practice bases, so that students can learn and exercise in a real working environment.

Integration of on- and off-campus teaching resources: Utilizing on- and off-campus resources to build an engineering practice education platform to provide students with more diverse learning and practice opportunities.

Concept of curriculum objectives centered on students' creative abilities: To form the concept of curriculum objectives and curriculum content centered on students' creative abilities, and to encourage students to take the initiative to learn and innovate.

Harmonious and symbiotic teacher-student interaction classroom: create a harmonious and symbiotic teacher-student interaction classroom atmosphere and encourage students to actively participate in classroom discussions and exchanges.

Intelligent classroom teaching scenarios: using modern technological means, such as artificial intelligence, virtual reality, etc., to build intelligent classroom teaching scenarios and improve teaching effects.

Integration of learning resources: Integrate all kinds of learning resources, including online courses, e-books, academic papers, etc., to provide students with rich learning materials.

Undergraduate Research as an Important Vehicle for Cultivating Innovative Abilities: Undergraduate research is taken as an important way to cultivate students' innovative abilities, and undergraduate research programs integrating diversity and interdisciplinarity are set up to encourage students to participate in scientific research activities and enhance their innovative abilities.

Although domestic universities have made many efforts and explored the cultivation of undergraduate innovation and practice ability, they still face many challenges. Problems such as the disconnection between curriculum and market demand, uneven distribution of teaching resources, insufficient professional development of teachers and limited practice opportunities for students are still prominent. The existence of these problems restricts the improvement of students' innovative practice ability.

3. Necessity of Cultivating Innovative Practical Skills

3.1. The Needs of the Times and Social Development

In today's society, there is a growing demand for high-caliber talents who are able to promote social development and possess the ability to practice innovation and the spirit of innovation. As an important base for talent cultivation, higher education institutions have the responsibility to cultivate talents with active exploration spirit and innovation ability, which is their unshirkable historical mission.

3.2. The Needs of Higher Education Development

Higher education is a specialized stage of education on top of basic education, which is not only tasked with imparting professional knowledge and skills, but also has the important functions of promoting knowledge innovation, training innovative talents and facilitating the employment of students. At this stage of education, students are encouraged to develop critical thinking, independent research skills and the ability to solve complex problems in order to adapt to rapidly changing social and economic needs. In addition, higher education institutions serve as important bases for scientific research and technological innovation, contributing to the country's scientific and technological progress and economic development. By working closely with industry, higher education also helps bridge the gap between theory and practice, providing students with practical work experience that better equips them for their future careers[3] .

3.3. The Need for Self-Generated Development of Undergraduate Students in Higher Education

The innovative and practical ability of undergraduates in the new era is an important source of constituting new-quality productivity. In the era of knowledge economy and digitalization, the composition of new quality productivity no longer depends only on traditional material resources and labor, but more on non-material assets such as knowledge, information, technology and innovation, etc. By improving undergraduates' own innovation and practice ability, we can make them change from "job-seekers" to "entrepreneurs". Entrepreneurs".

4. Exploration of the Cultivation Mode of Innovative Practical Ability of Undergraduates in Computer Science and Technology

4.1. Developing Innovative Personnel Training Programs Starting with Teaching Plans

1. Provide innovative practice courses to systematically enhance undergraduates' innovation ability through practice courses.

2. Curriculumize the tournament tasks and define the objectives and requirements of the tournament, including technique, strategy and teamwork. These objectives will form the basis for course design.

3. Increase the proportion of practical sessions of courses, especially the proportion of comprehensive and design-oriented practical courses, so that undergraduates also have many opportunities to practice.

4. Encourage cross-disciplinary electives to provide a guarantee of knowledge reserve for innovative practical activities.

4.2. Practical Approach

Incorporating RoboMaster Mecha Masters design examples. Teachers play a leading role while students are at the center of the learning process. Through a teaching model that integrates knowledge transfer, case study and competition motivation, students are encouraged to work in teams to actively explore[4] [5] . Specific practical methods include:

1. Competition publicity

Adopting the mechanism of "collaborative guidance", the professional teachers act as team instructors, take the college students' innovation clubs as teams, carry out individual, team and grade level coverage, take the college students' innovation and entrepreneurship training program as a guide, and divide the students' teams into small groups for learning[6] .

At the entrance education stage, a professional introduction is provided through a campus tour for all new students, including the format and content of relevant disciplinary competitions and programs, as well as the corresponding competency requirements. At the same time, the relevance of these activities to the curriculum and students' own studies is explained so that students can have a preliminary understanding and make their own academic plans accordingly. In addition, senior professional teachers are assigned as class teachers for new students to guide students to update their learning concepts, change their learning styles and improve their learning abilities. Students are encouraged to participate in relevant competition training and courses, and experienced competition teachers are responsible for the training and guidance, and students are motivated to participate in various competitions in order to accumulate experience, to further clarify the theoretical knowledge they need to master, and to practice logical thinking and practical skills.

2. Competition organization

First, team gradient division. According to the age of the team members, personal ability, specialty into the appropriate level or group, in the lower team gradient, novice and less experienced team can learn and grow in a more relaxed environment, and will not be faced with too fierce competitive pressure at the beginning, reasonable team gradient division is conducive to the sustainability of the team's development, the cross-disciplinary combination is conducive to promote the professional knowledge and ability of the complementary, so that the team The combination of disciplines is conducive to the sustainability of the team's development.

Second, competition registration, designate a full-time staff responsible for managing the registration process of the competition. This responsibility includes first collecting information related to the competition and introducing to students in detail the specific matters of each competition, such as the time of the competition, the level of participation, the content of the competition, the competition method and the setup of awards and so on. Subsequently, the registration time and steps for the competition are announced, information on previous competitions is organized, and students are assisted in completing the registration process.

Third, the competition guidance, the establishment of a specialized faculty guidance team, according to the different tasks of R & D, the development of corresponding training programs and training plans. Planning vacation time schedule, formulate competition R & D progress advancement table, strictly according to the task side to promote the preparation process.

3. Competition training

The R&D requirements of the robot are subdivided into projects, and the R&D task requirements, R&D progress requirements, and knowledge requirements for each sub-function are clearly defined. The training is further subdivided into two directions: embedded system competition training and software technology competition training. In this way, students can focus on their own interests and energies, and carry out in-depth study and research in specific areas, thus realizing rapid and efficient skills enhancement.

First, robot design requirements are introduced, emphasizing the integration of theory and practice. Analyze the robot design objectives, including mechanical engineering, electrical engineering, computer science and artificial intelligence. Student-centered[7] , based on the mastery of course theory, students are shown excellent design cases. These cases are described in detail in terms of practicability, workload and degree of difficulty, and practical guidance is provided.

Second, guide the group to divide the work into cooperative groups. Split the robot design requirements into projects, follow the principle of complementary abilities, according to the comprehensive ability of the students, using the strategy of "taking the strong with the weak" to form cooperative groups. The students will conduct collaborative exploration and innovation within the group, and work together to complete the functional design, program development, structural design and so on. This teaching system combines the motivation of participating in RoboMaster with course learning, which not only maintains the relevance of the content, but also adopts the combination of self-selected topics and fixed themes, and realizes the form of "promoting learning through competition".

Thirdly, a case database was constructed to facilitate practical learning. By collecting teaching feedback and summarizing experience, we have built a database containing typical competition cases to provide students with comprehensive, integrated and extensive practical training. Such practical training is conducive to improving students' problem-solving skills and enhancing their practical abilities.

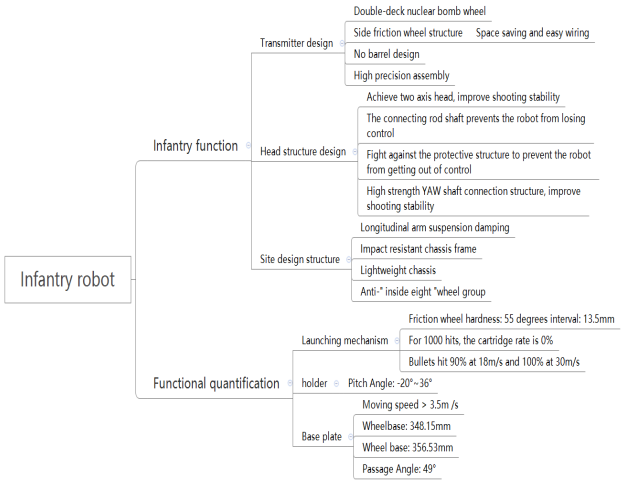

Fig 1. Functional analysis of infantry robot development

4.3. Implementation Cases

Take the infantry robot research and development as an example. Infantry robots play an extremely central role in the field of play, tactical positioning: ground defense, ground attack, all-terrain maneuvering; the main functions: precision shooting, intelligent fire control, rapid movement, active defense, quick response to control, rapid dismantling and maintenance; according to these tactical positioning and functional requirements[8] .

1. Developing a design program

Mechanical technology ideas: high-precision launch mechanism, fire control limit; linkage Pitch axis, high-strength head and chassis connecting structure; longitudinal arm independent suspension, lightweight chassis design, high-strength wheelset structure;

Electronic control technology ideas: fast response gimbal, low-latency control system, high-precision attitude solving, capacitor stabilization charging and discharging technology, prediction algorithm;

Visual design idea: high accuracy and high frame rate to recognize armor plates.

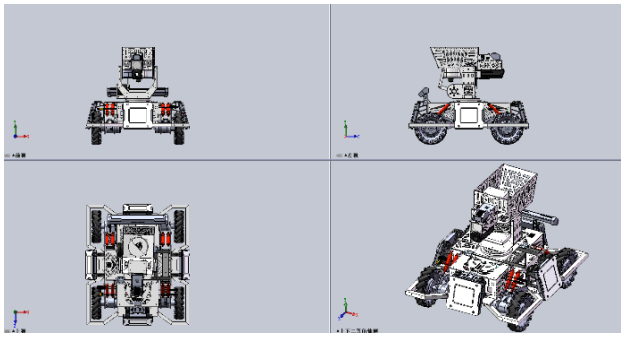

Fig 2. Infantry robot form

2. Overall structural overview

The infantry gimbal adopts the structure of upper feeding gimbal, and the Pitch axis adopts the linkage structure; the original launching mechanism adopts the snail motor without

feedback, which leads to the inability of closed-loop control; the team decides to replace it with the 3508 motor under the reference to the solutions of various colleges and universities to carry out the closed-loop PID control, and the problem has been greatly improved. The chassis structure adopts aluminum square tube and epoxy board combination to build the body, the body is more solid; the infantry internal wiring is fully wrapped design, the whole car non-load-bearing parts are hollowed out design, reducing the weight of the body at the same time, increasing the safety, aesthetics and the convenience of wiring.

3. Chassis structure

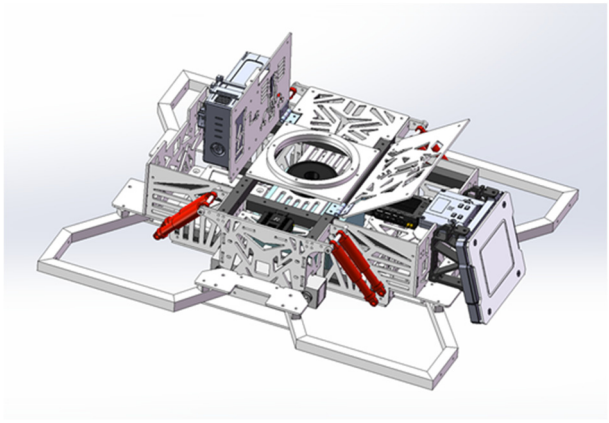

Fig 3. Chassis model

Adopting one-piece chassis package, the internal wiring is wrapped in a full range, avoiding the hidden danger of the chassis wiring being exposed and hung up; the maintenance cover plate is designed in the front and rear of the body, which is convenient for wiring and maintenance; and the frame as a whole is reinforced by a 15mm aluminum square tube, together with epoxy plates. The chassis frame is strengthened to resist deformation, and the connection between parts is more stable, which provides the foundation for flying slope.

Wheel set is the infantry in the field with high mobility guarantee, the new season infantry use four wheels longitudinal arm independent suspension, the mobility and adaptability of the whole vehicle to strengthen the longitudinal arm suspension design, can alleviate the infantry flying slope after the landing of the impact brought about by the; wheel set of the various parts and components of the nested each other, greatly reducing the McNamee wheel transverse force brought about by the wheel set of the overall deformation as well as metal fatigue caused by repeated deformation of metal parts.

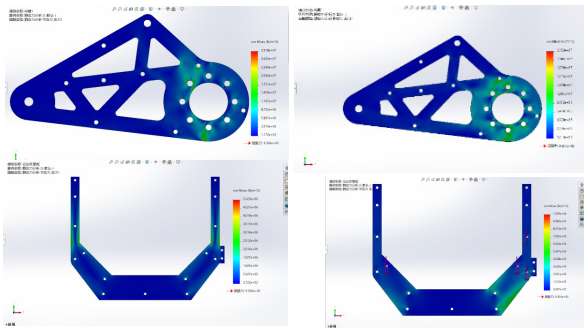

Fig 4. Static dynamic analysis of longitudinal arm support plate and head support plate

The mechanical structure of the wheelset is simple and stable, and it is easy to repair and replace the McLamb wheel, motor and shock absorbing spring, and all the parts can be replaced within three minutes.

4. Stress analysis of components

The longitudinal arm and the head support have high requirements, the infantry high-speed movement and the impact after the flying slope are a huge test for these two structures, the longitudinal arm structure will not produce obvious deformation under the 400N simulation; at the same time, the head support is filled with 3D printed parts between the head support, which can absorb the impact after the flying slope more effectively.

5. Embedded real-time operating system

Using the RT-Thread Nano system, which is a minimalist version of a hard real-time kernel developed in C with object-oriented programming thinking and a good code style, it is a tailorable, preemptive real-time multitasking RTOS. its memory resource footprint is extremely small, and its functionality includes a relatively complete set of task processing, software timers, semaphores, mailboxes, and real-time scheduling real-time operating system features. This operating system is simple, convenient and efficient for embedded development [9].

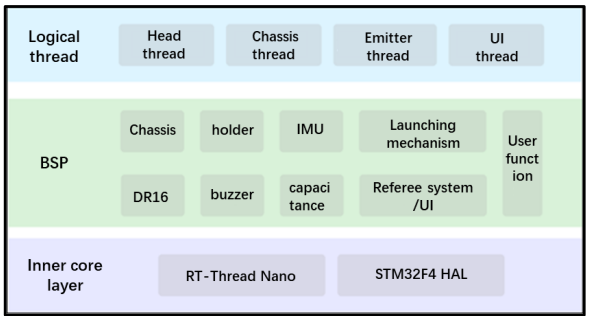

Fig 5. Software Block Diagram for RT-Thread Nano

6. Chassis control

The chassis uses a McNamee wheel solution to improve the robot's omnidirectional mobility, and utilizes a 1A, 24-wire slip ring to realize the function of a small gyro.

7. Wheat wheel solving

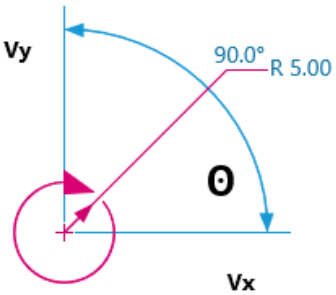

Fig 6. McNamee wheel motion analysis

Definition: take the vector pointing from the center of the chassis to the wheel axle as R; take the velocity vector of the motion of the wheel axle as V; take the velocity component of the wheel axle along the direction perpendicular to Θ as Vr; Equation.

$V = Vt + Θ*R$

Calculate the components of X and Y separately:

$\{Vx = Vtx - Θ*Ry$

$\{Vy = Vty + Θ*Rx$

8.PID control algorithm

In process control, PID controller, has been one of the most widely used automatic controllers; PID control has been one of the many control methods most commonly used control algorithms, PID algorithm calculation process and the output value (OUT) has a direct function. PID controller to regulate the output, is to ensure that the deviation value (e value) is zero, so that the system to achieve a desired stable state. Here the deviation (e) is the difference between the given value (SP) and the process variable value (PV). The output M(t) is a function of the proportional term (P), the integral term (I), and the differential term (D)[10].

M(t)=KC*e+ KC* +Minitial+ KC*TD* (1-1)

The scale term is: a function of the current error sampling.

The integral term is: a function of all error terms from the first sampling period to the current sampling period.

The differential term is: a function of the current error sample and the previous error sample.

9. Selection of controller P,I,D

In robot control, we commonly use two types of control PD and PID:

10. Proportional differential control law (PD)

Differential has an overrun effect to reduce the delay of the robot actuator, which has a significant effect on improving the dynamic performance index of the system when the differential term is set properly. Therefore, in order to improve the stability of the system and reduce the dynamic deviation, etc., PD controllers are used in a large number of robots, such as toggle wheel motors, friction wheel motors, and chassis motors.

11. Proportional Integral Differential control law (PID):

PID control law is a more ideal control law, which introduces integral on the basis of proportionality, which can eliminate the residual difference, and then add the differential role, and can improve the stability of the system, but the parameter adjustment is more cumbersome. So the PID controller is only applied to Yaw axis motor and Pitch axis motor which have high requirements for accuracy, response speed and torque.

12. Downrange attitude solution:

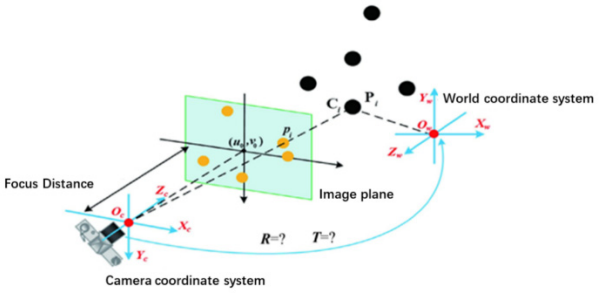

Fig 7. Camera imaging model

The attitude solution of the lower machine position is the real coordinates of the robot itself obtained through the feedback data of the MPU6500 gyroscope, and only by obtaining more accurate attitude information can the robot's attitude be controlled. In the process of attitude solution, due to environmental interference, the solution angle drift is serious, so the geomagnetic sensors and accelerometers are used for data fusion, and the attitude solution algorithm that fuses complementary filtering and Kalman filtering is used here. The advantage of the complementary filtering algorithm is that it has a small amount of operation and can suppress noise and drift, but it's up to frequency is not easy to determine. The Kalman filter algorithm has a strong real-time performance and a simple structure, but it is not applicable to nonlinear systems and needs to be improved.

In synthesis, firstly, the complementary filter is used to fuse the geomagnetic sensor and accelerometer to improve the measurement accuracy, and the fused attitude information is used as the observation, and then the improved adaptive Kalman filter is used to compensate for the presence of dispersion in the filtering process on the race course. Meanwhile, the range interval of the gyroscope is at [-180°, 180°], once exceeding the range, the data will be reloaded, which does not meet the system requirements. Try to add the cumulative calculation method on the basis of the original data, which is mainly applied to the Yaw axis of the robot.

Camera imaging model shown in the figure above, where Oc is the optical center of the camera, f is the distance from the optical center of the imaging plane (known as the focal length), the camera optical axis and the imaging plane intersected in the main point (uo, vo).

The goal of PnP is to utilize the spatial reference points {Pi,i=1,2.... .n} and its corresponding image projection point {p,i=1,2....} to calculate the rotation R and translation t between the camera coordinate system and the world coordinate system.

Based on the above theory, the center of the real armor plate is taken as the center of the world coordinates, and according to the length (h) and width (w) of the armor plate, the four feature points (h/2,w/2), (h/2,-w/2), (-h/2,-h/2), (-h/2,w/2) of the world coordinates are localized; the corresponding four feature points are found in the image projection, and finally, using the cv2. solvePnp() function to solve the rotation and translation matrices, the real position of the armor plate in the world coordinates can be obtained, and the tracking and localization can be realized by fusing it with the coordinates of the lower aircraft position.

5. The Significance of "Promoting Education Through Competition" for Practical Education of Human Beings

As an innovative attempt to reform the teaching model, the "competition for teaching" model integrates competition activities into the core part of the students' learning process and closely relates the results of the competition to classroom teaching. The teaching reform by adopting the "competition for teaching" model has multiple important meanings: it can stimulate students' enthusiasm for learning. In traditional teaching methods, students often feel that the content is single and boring, and lack of motivation and interest. The "competition for teaching" model can ignite students' passion for learning, prompting them to engage in learning activities more actively and spontaneously.

Secondly, it can enhance students' learning efficiency." The "competition for teaching" model is competition-driven, student-centered and teacher-led, and enhances students' independent learning and self-management skills.

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