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Research on Visual Simple Pendulum Experimental Device Based on Angle Sensor and Its Application in Education

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ABSTRACT
This paper aims to solve the shortcomings of traditional simple pendulum experimental device in accuracy and visualization, and puts forward a visual simple pendulum angle experimental device based on angle sensor. Combined with electromagnet current control technology and closed-loop system design, it realizes accurate measurement of simple pendulum motion angle and visual display of experimental data. This paper briefly introduces the technical scheme, innovation and educational significance of the system. This device not only contributes to the development of physics education and scientific research, but also provides a new tool for popular science education, which has a wide application prospect and important promotion value.

KEYWORDS
Simple pendulum experiment; Angle sensor; Visualization; Educational application

1 Technical scheme

1.1 Background technology

The simple pendulum experiment is to lift a heavy hammer with a negligible weight and make it swing left and right. When the swing angle is 0 degrees, the combined force on the heavy hammer is equal to the gravity of the ball itself. The simple pendulum is a device that can generate reciprocating swing. One end of a thin rod without weight or an inextensible flexible rope is suspended at a certain point in the gravity field, and the other end is fixed with a heavy ball to form a simple pendulum. If the ball swings only in the vertical plane, it is a plane simple pendulum; if the ball swings only in the vertical plane, it is a spherical simple pendulum.

In the simple pendulum experiment, if you need to obtain the swing angle information in the simple pendulum experiment, you can use the displacement sensor or the angle sensor, which is used to detect the angle. There is a hole in its body, which can match the angle axis. When connected to RCX, the angle sensor will count once every 1/16th revolution of the shaft. When rotating in one direction, the count increases, and when the rotating direction changes, the count decreases. The counting is related to the initial position of the angle sensor. When the angle sensor is initialized, its count value is set to 0, and it can be reset by programming technology if necessary.

The simple pendulum experiment in the prior art can't accurately obtain the motion angle of the swinging component when it is used, and the obtained data is usually presented in the form of numbers, which affects people's understanding and judgment efficiency. From this, a visual simple pendulum experimental device based on an angle sensor is proposed, which, through innovations in pendulum swing methods and data analysis, achieves precise control of the pendulum's angle and position..

1.2 Technology: angle sensor and visualization

The pendulum experiment is to lift a weight with a mass m with a thin line with negligible weight and make it swing left and right. When the swing angle is 0 degrees, the resultant external force on the weight is equal to the gravity of the ball itself. The pendulum is a device that can produce reciprocating swing. One end of a weightless thin rod or non-extensible soft rope is suspended at a certain point in the gravity field, and a pendulum bob is consolidated at the other end to form a pendulum. If the pendulum bob is limited to swing in the vertical plane, it is a planar pendulum, and if the swing of the pendulum bob is not limited to the vertical plane, it is a spherical pendulum.

In the pendulum experiment, if it is necessary to acquire the swing angle information in the pendulum experiment, a displacement sensor or an angle sensor can be used. The angle sensor is used to detect the angle. The pendulum bob has a hole in the sphere to fit the angle shaft. When attached to the RCX, the angle sensor counts every 1/16 turn of the shaft. When rotating in one direction, the count increases, and when the direction of rotation changes, the count decreases. The count is related to the initial position of the angle sensor. When the angle sensor is initialized, its count value is set to 0, and it can be reset by program if necessary.

The single pendulum experiment in the prior art cannot accurately obtain the motion angle of the swing component

when in use, and the obtained data is usually presented in the form of numbers, which affects people's understanding and judgment efficiency. Therefore, we propose a visual single pendulum angle experimental device based on an angle sensor.

In view of the above problems, the device provides a visual single pendulum angle experimental device based on an angle sensor, which has the displacement of the pendulum bob drives the shaft of the angle sensor body to rotate through the swing rope, so as to accurately obtain the swing angle data of the pendulum bob in the swing experiment; The model and data can be presented through the visual presentation module, so that the experimental data can be presented more intuitively in the form of models.

The technical scheme of this device is as follows: The visualized simple pendulum angle experimental device based on an angle sensor includes the following components:

Experimental component: It comprises a base, with a bracket fixedly connected to the top of the base. An angle sensor body for collecting data of the simple pendulum is arranged above the bracket, and the angle sensor is equipped with an angle axis. A swing rope is arranged below the angle sensor, and a pendulum bob is fixedly connected to the bottom end of the swing rope.

Microcontroller: The output end of the microcontroller is signal-connected to a data processing module for processing experimental data, and also signal-connected to a model construction module for generating simple pendulum experiment models.

Model construction module: It is signal-connected to the output end of the microcontroller and is used to construct the simple pendulum model based on experimental data. The output end of the model construction module is signal-connected to a visual presentation module, which is used to visually present the constructed simple pendulum experiment model.

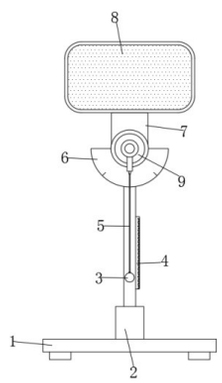

Figure 1 Schematic diagram of overall structure

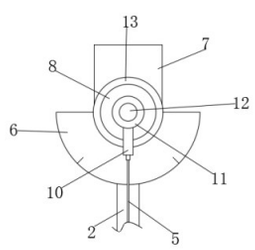

Figure 2 Angle sensorSchematic diagram

1. Base; 2. Bracket; 3. Pendulum bob; 4, Scale plate; 5. Swing rope; 6. Angle plate; 7. Microcontroller;
8. Display screen; 9. angle sensor body; 10. Rope installer; 11. Ring; 12. Angle axis; 13. Mounting ring.

1.3 Technical benefits

In this design, the swing rope of the single pendulum is fixed on the shaft of the angle sensor body. When the pendulum bob is swinging experiment, the displacement of the pendulum bob will drive the shaft of the angle sensor body to rotate through the swing rope, so that the swing angle data of the pendulum bob in the swing experiment can be accurately obtained. Combined with the weight of the pendulum bob, the length of the swing rope and the pulling height of the pendulum bob, it is helpful to the analysis of the single pendulum experiment and makes the analysis result more accurate.

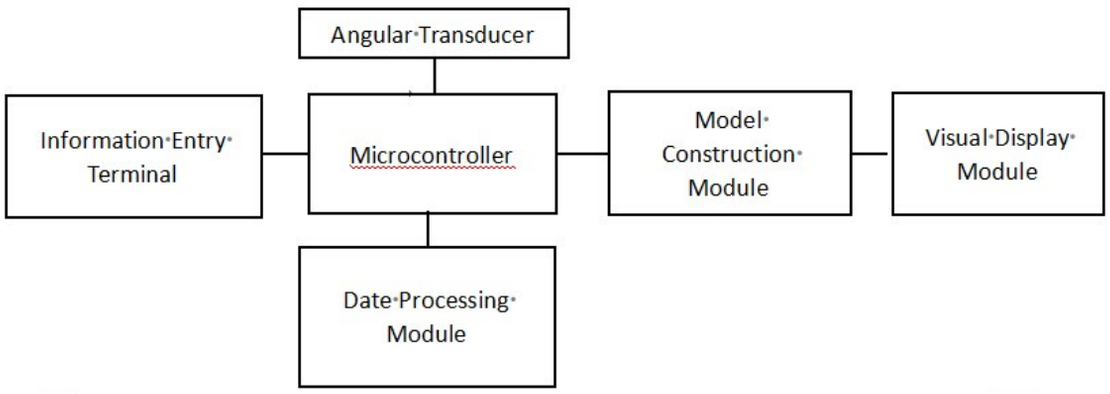

Figure 3 Schematic diagram of pait of the microcontroller systemm

By setting the data processing module, the model building module and the visual presentation module, the angle data in the pendulum experiment can be obtained and the basic data can be imported when in use, and then the above data can be screened and classified, converted into model data, and the model of the swing experiment can be constructed according to the model data, and the model and data can be presented by the visual presentation module, so that the experimental data can be presented in a model way more intuitively and the experimental results can be convenient for experimenters to understand the experimental results.

1.4 Design and implementation of visual interface

Figure 4 Visual Interface

Aiming at the visual pendulum experimental device based on angle sensor, when designing and constructing the visual interface, the actual needs of users and the convenience of operation of the experimental equipment are deeply analyzed. The interface layout is mainly divided into three parts: real-time monitoring area, data presentation area and control management area. The real-time monitoring area graphically displays the motion state of the pendulum, including the position, speed and acceleration of the pendulum ball. These data are collected and processed by the angle sensor in real time, and then displayed on the interface in the form of dynamic charts, allowing users to directly observe the motion path and state transition of the pendulum. The data presentation area is responsible for displaying the detailed data of the experiment, such as the angle, angular velocity, kinetic energy and potential energy of the pendulum ball and other important parameters, and provides data export function. Users can export the experimental data into Word or Excel format for further analysis and processing. The control management area allows users to set experimental parameters, such as pendulum length, pendulum ball mass, etc., as well as to start, pause and reset the experiment, and also adjust the frequency and accuracy of data acquisition. In the technical implementation, efficient data acquisition module and real-time data processing technology are adopted to ensure the accuracy and real-time of data. At the same time, professional interface development tools are used to create an intuitive and easy-to-use graphical interface. The application of these technologies ensures that the visual interface has rich functions, while maintaining simple operation and high accuracy of data.

1.5 Main functions

The main functions are:

(1) The data acquisition module is responsible for real-time acquisition of the angle data of the single pendulum motion through the connected angle sensor, supporting the setting of parameters such as sampling rate and data accuracy, and storing the acquired data into the database.

(2) The data pre-processing module performs pre-processing operations such as filtering and denoising on the collected raw data in order to improve the data quality and provide a reliable data base for subsequent analysis.

(3) The motion visualization module uses the graphical interface to display the trajectory, speed, acceleration and other dynamic information of the single pendulum motion in real time, and supports the switching of two-dimensional and three-dimensional views, so as to enhance the user's understanding of the motion process.

(4) Data analysis module provides various data analysis tools, such as period calculation, frequency analysis, phase difference measurement, etc. It supports user-defined analysis algorithms for in-depth mining and analysis of single pendulum motion data.

(5) The report generation module automatically generates an experiment report or analysis document based on the data sets and analysis results selected by the user, including charts, data tables, analysis conclusions, etc., which is convenient for users to share and archive. 6. The system settings and management module manages system-level settings such as user accounts, privilege assignment, sensor configuration, data storage paths, etc., to ensure the safe and stable operation of the system, and provides system log viewing and error tracking functions.

2 Educational dimension

Physics experiments are an important way to understand the world, an important way of studying scientific problems, and an important means of understanding abstract concepts. Demonstration experiment is an important teaching tool for physics teaching, which not only enriches the teaching content, but also attracts students' classroom attention and helps to improve students' learning interest and motivation. And the experimental apparatus is an important core material basis for experiments; this device provides new apparatus and methods for physics demonstration experiments, increasing the content of physics teaching, and for the students to enrich the physics is both important and more abstract concept of conservation. At the same time, it also enriches the way for students to learn physical knowledge and experience physical phenomena, enriches the content of teachers' classroom teaching, and consolidates students' mastery of physical knowledge. The law of conservation of mechanical energy means that under the condition that only gravity or elasticity does work on an object (or without the action of other resultant external forces), the kinetic energy (including rotational kinetic energy and translational kinetic energy) and potential energy (including gravitational potential energy and elastic potential energy) of an object are transformed into each other, but the total amount of mechanical energy stays the same. The law of conservation of mechanical energy is a very important law in secondary school physics teaching as well as an important law in the whole physics. The educational significance of the closed-loop system of visualized pendulum angle sensor and electromagnet current is to help secondary school students to rationalize the combination of theory and experiment, which can be suitable for the present and future education with the continuous improvement of experimental apparatus. There are the following meanings and values in the educational dimension :

(1) Innovative application of educational technology: by introducing angle sensors and visualization technology, the device breaks the limitations of traditional single pendulum experiments, makes the measurement of swing angle more accurate, and provides strong technical support for physics teaching.

(2) Enhance students' learning experience: the visualization single pendulum experimental device can transform abstract physical concepts (such as kinetic energy and change of gravitational potential energy) into intuitive and vivid visual effects, which helps students better understand and master physical knowledge such as the law of conservation of mechanical energy.

(3) Cultivate students' practical ability and innovative spirit: The device supports students' independent exploration and encourages them to come up with new experimental solutions and problems, which helps to cultivate students' practical ability and innovative spirit. Promote the reform of science education: the device embodies the deep integration of modern science and technology and education, which helps to promote the reform of science education in China and improve the quality and level of physics teaching. Broaden the channels of science education: besides being applied in school education, the device can also be used for science education, so that more people can understand the principles of physics and experimental methods, and improve the scientific literacy of all people.

(4) Promote interdisciplinary teaching: the device can be combined with other disciplines (such as mathematics and computer science) to carry out interdisciplinary teaching and improve the comprehensive quality of students.

(5) Enhance China's competitiveness in the field of international science and technology education: the device will help to enhance China's status and influence in the field of international science and technology education, and cultivate more excellent scientific and technological talents for China.

3 Future Prospects

Wide Application in Education: The innovative single pendulum experimental device proposed by this device is expected to be widely used in education, helping students to better understand the basic principles such as the Law of Conservation of Mechanical Energy in Physics, and improving the quality and effect of physics education.

(1) Facilitation of scientific research: The device will provide great convenience for physics research and other scientific endeavors, helping researchers to obtain more accurate and intuitive experimental data and results through high-precision and visualized experimental means.

Advancement of science education: The innovative experimental device will not only help promote science education, but also enable the public to understand the basic principles and phenomena of physics more intuitively, and improve the popularization rate of scientific knowledge.

(2) Possibility of interdisciplinary application: Whether the technology and principles of the device can be applied to experiments in other fields of physics, such as pendulum motion, vibration analysis, etc., needs to be further explored and developed.

(3) Commercialization and market promotion of the device as an important tool and equipment in the field of physics education and research.

(4) Technological innovation and iteration: With the development of technology and user feedback, technological innovation and iteration will be continued in the future to further improve accuracy, stability and user experience.

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