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Simulation of the motion of a pendulum

Tianhui Zhang

New channel, Shenyang, 110002, China

Tt060913@qq.com

Abstract. The project's objective is to simulate movement in the study and analysis of motion simulation problems and to propose simulation algorithms based on numerical calculation methods. It has many practical application values. In engineering and science, it is often necessary to simulate and analyze the motion of the fold to study the motor and dynamic properties of the fold, providing the theoretical basis and solutions to practical problems. With the support of modern computers and numerical computing technology, the problem of motion simulation has become a popular research direction. Many scholars and engineers have proposed different numerical calculation methods and simulated algorithms to simulate the motion process of the fold and analyze its motion laws. This article introduces the basic knowledge of physics and the formulas of motion, as well as some important concepts and theories related to motion. The motion simulation algorithm was then analyzed and discussed in detail. Subsequently, numerical calculations were prepared using MATLAB software, and simulated experiments were conducted using examples to analyze dynamic changes. Finally, the prospects for the future direction of research are presented. Therefore, if the initial speed is the same, the width and length of the time will increase.

Keywords: numerical calculation methods, MATLAB, change initial speed.

1. Introduction

A pendulum is a system that produces recurrent oscillations, with one end of an unextendable string or thin rod hanging at a certain point in the gravitational field and the other end of a rigid, heavy ball fixed to form a single spin. For ease of handling, we assume that the line is a long string that can be neglected and not stretched; the radius of the ball is much smaller than the length of the line, thus ignoring the size of a ball, and it is considered a quality point.

The monocouple consists of a smaller mass object (a monocouple ball) and a lightweight, fine line, usually hanging on the support. A single bow ball is influenced by gravity and moves along an arc with cyclic and gradually weakening amplitude. The laws and cycles of the motion of the single swing are related to the weight, length, and initial angle of the ball, so the movement of the single swing is an important experiment in the study of mechanics, dynamics, and vibration.

The accuracy of the simulation results depends on the calculation methods and parameter settings used and usually requires error analysis and accurate control to ensure the reliability of the results. Multiple methods and tools can be used to simulate single swing movements, such as Eurafa, Lagrange, MATLAB, etc. The accuracy of the simulation results depends on the calculation methods and parameter settings used and usually requires error analysis and accurate control to ensure the reliability of the results. Simulation of single swing movements can be used in academic research and engineering design; for example, it can be applied to mechanical control systems, astronomy, computer animation, etc.

The primary purpose of this dissertation, titled "Simulation of the Motion of a Pendulum," is to advance our understanding of pendulum dynamics through advanced computational simulations and to explore the practical applications of this knowledge across various disciplines. This research endeavors to achieve several specific objectives: to delve into the theoretical foundations of pendulum motion, encompassing classical mechanics, nonlinear dynamics, and the mathematics of oscillatory systems. By establishing a robust theoretical framework, this work aims to provide a comprehensive understanding of the underlying principles governing pendulum behavior.

To develop and implement advanced computational models and simulation algorithms capable of accurately replicating the behavior of pendulum systems under a wide range of conditions. The purpose is to harness the power of modern computing to simulate pendulum dynamics with precision and fidelity.

2. Solving the linear ordinary differential equation:

Through reading the comprehensive paper on a class of high-level Euler equations, I gained a deeper understanding of Euler's equation [1], The first and second stages of the ordinary differential equation as a carrier, the application of variable replacement in the query solution was analyzed and summarized, thereby expanding the variable substitution method in the solution of ordinary variable equation [2]. Then, I read a paper on the problem of solving a linear equation of a class of descendable secondary variable coefficients and discussed a solution of a special secondary differential coefficient of a series of linear equations. The solutionability of the linear differential equation $u(x)y''+v(X)y'+w(x),y=0$ is studied using the degradation method of the variable coefficient and so solved this linear ordinary differential equation[3].

$$\theta'' = -g*\sin(\theta) \ldots (1)$$

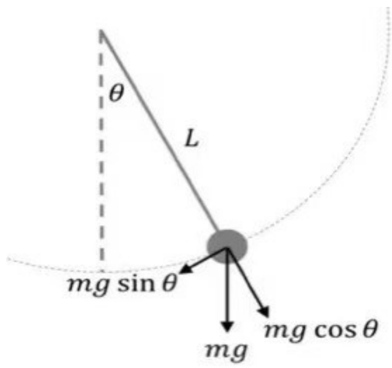

Figure 1. The motion of the pendulum.

Figure 1 shows the motion of the pendulum where θ is the angle from the negative vertical axis, and g is the gravitational constant. Initial conditions are θ(0)=45° and θ'(0)=0, and describe the initial position and the initial velocity of the pendulum.

Then use the Euler method to solve this equation, and we get the final equation, for the initial conditions are θ(0)=45° and θ'(0)=0.

Type the final equation on MATLAB, then plot the graph:

Algorithm 1.

```
1.for i=2:N
   theta(i+1)= 2*theta(i)-theta(i-1)-g*deltat*deltat*sin(theta(i));
end
2.plot(theta)
```

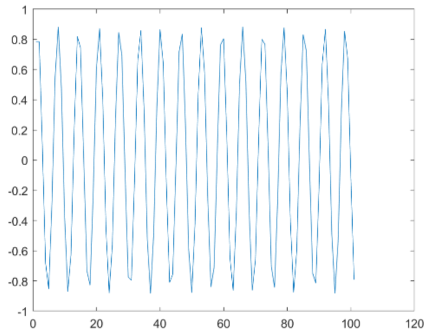

Figure 2. The motion of the pendulum at v=0.

As shown in Figure 2, the motion of the pendulum at v=0. A dynamic description of the single swing movement was made using MATLAB software to calculate the values. By comparing the theoretical calculations with the real data, it was found that they matched the real value. For this purpose, a basis was provided for determining the optimal swing angle for the actual one-swing experiment [4]. The method of study of the single swing movement cycle, written by the land column, proposes the direct method of calculating the motion cycle and gives the universal expression of the mono swing cycle so that the traditional method can be improved [5].

Changing the initial velocity to see the difference. Through specific algorithms, compare the calculation accuracy and efficiency of various high-level algorithms, give the corresponding numerical error and chart description, fully verify the advantages and shortcomings of class 2 high-grade methods, and provide a reference basis for the solution of practical application problems [6]. First, the linear elementary equation of the second variable factor is transformed two times in a row to the equivalent of a second type of vitamin-linear elemental equation. Then, the solution of the elementary Equation is solved, thus obtaining the requested problem exists a single continuous solution, and the solution is given [7].

Algorithm 2. at v=1(v is velocity):

```
1.  for i=2:N
        theta (i+1)=2*theta(i)-theta(i-1)-g*deltat*sin(theta(i));
    end
2.  plot(theta)
```

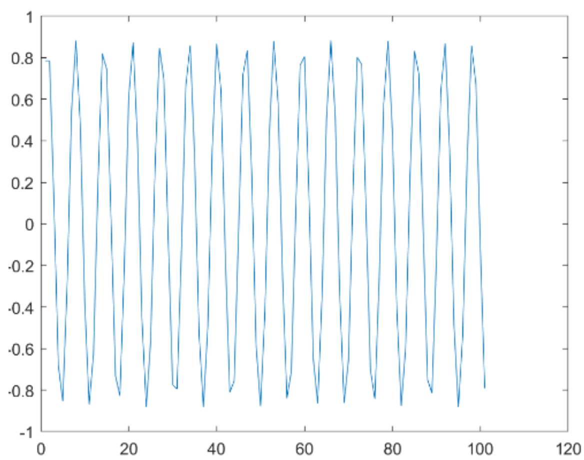

Figure 3. The motion of the pendulum at v=1.

Figure 3 shows how the pendulum moves at the initial velocity v=1. Then, continue the process by changing the initial velocity to V=2,3,4 and plot the graphs. Use methods and methods in combination with MATLAB software to analyze the monoclinic system, high accuracy, and small error [8]. The accurate period calculation of a single pendulum under the condition that the air resistance is neglected was given by numerical integration with Mathematica. Accordingly, some approximate period formulae described in references were compared by the curve fitting method of MATLAB [9].

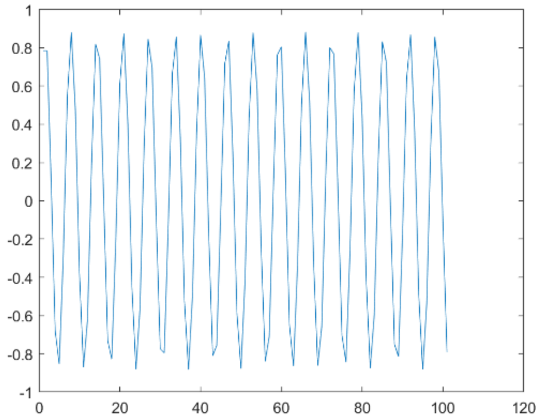

Figure 4. The motion of pendulum at v=0.

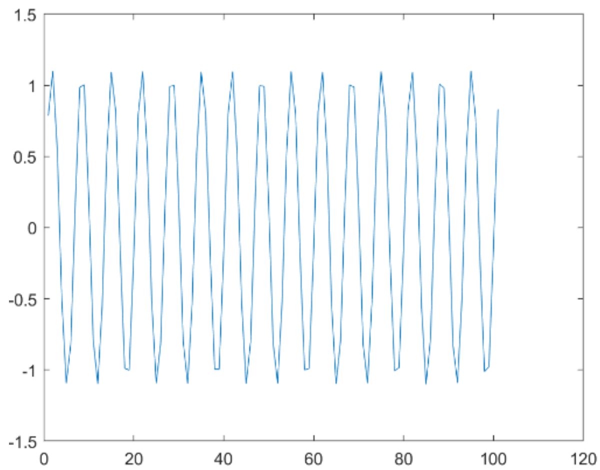

Figure 5. The motion of pendulum at v=1.

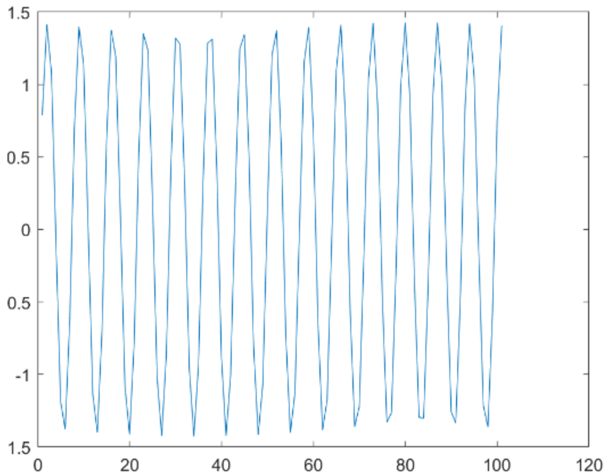

Figure 6. The motion of pendulum at v=2.

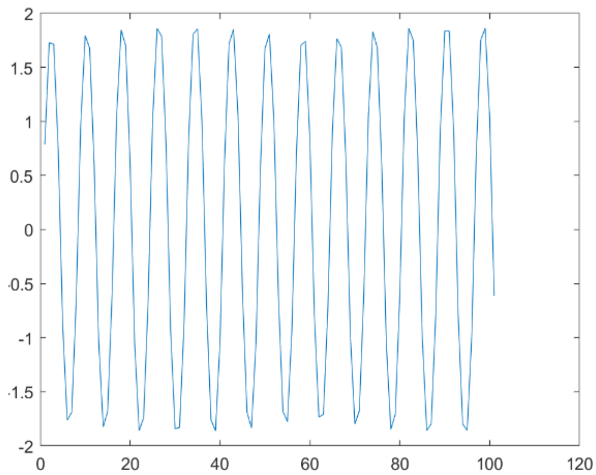

Figure 7. The motion of pendulum at v=3.

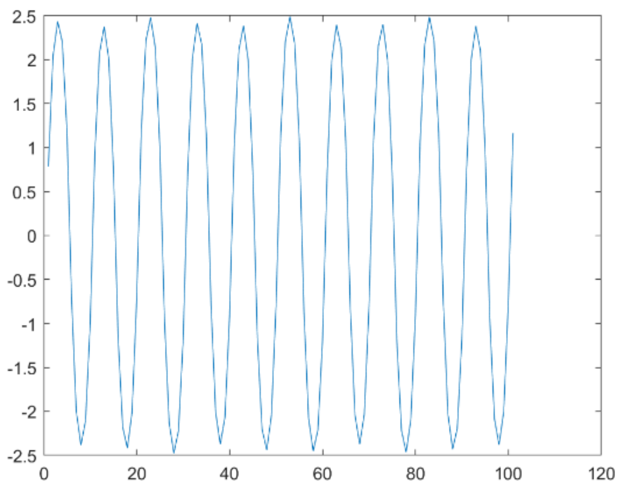

Figure 8. The motion of the pendulum at v=4.

Figures 4, 5, 6, 7, and 8 show the pendulum's motion and compare the initial velocity by graphs at v=0,1,2,3,4, respectively. At the same time, using MATLAB, accurate results in different periods are calculated, and follow-up curves are drawn based on these data. By comparing formulas and images, the cycles, frequencies, and magnitude of single-swing movements can be seen from these different images. The results showed that for unimpeded cycles such as oscillation, the larger the initial angle of the single swing, the greater the cycle of the mono swing. The nonlinear twisting cycle obtained in the numerical calculation is consistent with the result of the literature's aggregate resolution, with an error of less than 0.3% [10].

3. Conclusion

The same tiny ball was allowed to fall with varied initial speeds while maintaining the initial angle constant, and the study's conclusion—that as the initial velocity grows, the amplitude and period both grow—was achieved as a result. This discovery can be applied in many fields. For example, it can be used in a deep understanding of simple pendulum movement, which is a classic problem in Classical physics. Changing the initial speed of a simple pendulum can help to deeply understand the movement law and vibration characteristics of a simple pendulum, which is conducive to academic research and teaching.

The vision of flat motion simulation has great hope for further progress and interdisciplinary exploration. When we look to the future, several key areas draw our attention. Future advances in computational methods and technologies will lead to more sophisticated and efficient simulation of rotational motion. We expect to develop new algorithms and digital technologies that enable simulations to capture the complexity of behavior with unparalleled accuracy. Engineers can use these simulations to optimize structural designs, astronomers can simulate movements of celestial bodies, and biologists can study vibrational behavior in biological systems. There is great potential for interdisciplinary development. With increased computational and graphical capabilities, it has become more feasible to incorporate real-time interactive simulations into educational materials and outreach initiatives. It can potentially revolutionize science education by attracting students and promoting a deeper understanding of physics principles.

In addition to the academic community, there is also the potential to solve real-world challenges in practical situations. Engineers can use simulations to design energy-based collection systems or improve the stability of rotating structures. These practical applications can lead to far-reaching innovations in industries such as renewable energy and civil engineering. And the simulations developed here can serve as a valuable educational tool. They can be incorporated into science courses to enhance students' understanding of complex physical phenomena, and the realization of simulated actions is applied to computer graphics, animation, video games, and special effects. It helps to create a vibrant virtual environment that enriches the visual quality and reality of entertainment experiences.

At the same time, he can conduct research and experiments, and the simulator can be used as a virtual laboratory to conduct unrealistic or expensive experiments in the physical world. Researchers can explore the behavior of complex systems under various conditions and parameter settings.

In short, the study of this paper goes far beyond the boundaries of theoretical physics. By unlocking the complexity of penis dynamics, it opens the door to innovation and solutions in engineering, energy, astronomy, biomechanics, education, recreation, and scientific research. Understanding the practical impact of this movement is expected to shape cross-disciplinary progress and contribute to building a more informed and technologically advanced society. This work demonstrates the transformative potential of simulation movement in visual and application in our evolving world.

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