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Research on Obstacle Avoidance and Environment Adaptability of Snake Robot Based on Deep Learning

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Abstract

With the development and popularization of computer artificial intelligence technology, more and more intelligent machines are gradually produced. These intelligent machines have brought great convenience to people's lives.This paper studies the control method of snake robots based on environment adaptability, which mainly explains the construction and stability of multi-modal CPG model. In addition, this paper also studies the trajectory tracking and dynamic obstacle avoidance of mobile robot based on deep learning.

Keywords: Deep Learning; Snake-Like Robot; Obstacle Avoidance Ability

1. Introduction

With the emergence of intelligent robots, people's lives have become more intelligent. Although traditional robots have brought great convenience to the people, their skills are fixed. Nowadays, researchers combine deep learning with intelligent robots, which not only allows robots to have original fixed functions, but also have the ability to learn independently.This will surely bring extremely high learning efficiency and improve the extremely fast robot working accuracy, and this also omits tedious programming [1]. Intelligent robots have the ability to navigate and adapt to their environment in order to perform tasks and achieve their goals. One key aspect of this intelligence is their ability to avoid obstacles and navigate around them. This is particularly important for robots operating in real-world environments, where there may be a wide range of obstacles that the robot needs to navigate around in order to reach its destination.

There are several different approaches that can be used to enable a robot to avoid obstacles and adapt to its environment. One approach is to use sensors, such as lasers or radar, to detect the presence of obstacles and determine the robot's distance from them. The robot can then use this information to adjust its course and avoid the obstacle. Another approach is to use machine learning algorithms to teach the robot to recognize and avoid common obstacles. For example, a robot might be trained to recognize objects such as walls or furniture, and to navigate around them using pre-programmed behaviors. This approach can be particularly effective in dynamic environments, where the layout or composition of the environment may change frequently.

In addition to using sensors and machine learning algorithms, robots can also use a combination of both approaches to achieve greater adaptability and obstacle avoidance capabilities. For example, a robot might use sensors to detect obstacles in its immediate surroundings, while also relying on machine learning algorithms to recognize and adapt to more complex or unpredictable obstacles. Overall, intelligent robots that are able to adapt to their environment and avoid obstacles are becoming increasingly important in a wide range of applications, from manufacturing and logistics to search and rescue operations. These robots are able to operate safely and effectively in complex and dynamic environments, making them a valuable tool for a variety of tasks. As the technology continues to advance, we can expect to see even more advanced and sophisticated intelligent robots that are able to navigate and adapt to their environment with even greater ease and efficiency.

2. Research Literature

2.1. Construction of multi-modal CPG model

Biological principles of multimodal CPG model. Snake's long and narrow skeleton, soft body and various movements make it highly adaptable to the environment.It can choose different motions in different environments. Researchers have developed a snake-shaped intelligent machine based on the characteristics of snakes. This kind of machine retains the characteristics of snakes well. It can slide, roll sideways and change waveforms.In order to improve the environment of the snake-like robot, it also enables its CPG control model to be displayed in a multi-state form [2]. The biological principle of the multi-modal CPG model is shown in Figure 1.

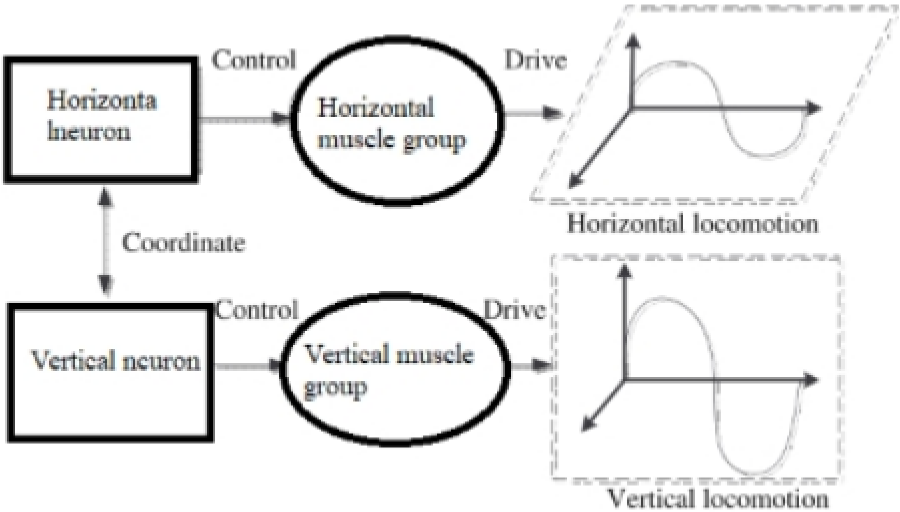

Figure. 1. Schematic diagram of nerve-muscle-motor coordination

Multi-modal CPG model. The construction of the CPG model includes two basic steps, namely the selection of neurons and the construction of connection patterns. The mathematical expression of neuron is shown in (1), (2), (3):

$$\theta_i = w_i + \Sigma c_{ij} sin(\theta_j - \theta_i - \varphi_{ij} \quad (1)$$

$$\Gamma_i = d_i \; r_i (R_i - r_i) \quad (2)$$

$$x_i = g\,(r_i sin\,(\theta_i)),\; g(u) = max(u, 0) \quad (3)$$

Equation (1) represents the phase coupling relationship between neurons, equation (2) represents the amplitude of the neural output, and equation (3) is the final output of the neuron [3].

The snake-shaped machine is composed of multiple joints, each single joint is a neuron group, and a neuron group is composed of two neurons, and the shape is shown in Figure 2.

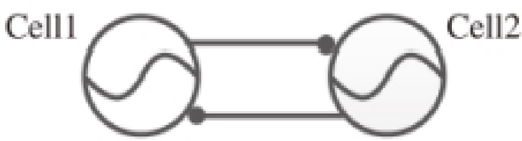

Figure. 2. Single joint CPG model

Since the serpentine machine contains a variety of movements, the serpentine machine is controlled by the neuron group of the horizontal joints when performing horizontal movements.It is controlled by the neuron group of the vertical joint during vertical movement. The connection of different movement groups of the serpentine machine uses an appropriate number of nodes to construct a CPG model.This model can produce a variety of output modes by adjusting external excitation, so it is called a multimodal CPG model [4]. The structure of the multi-modal CPG model is shown in Figure 3.

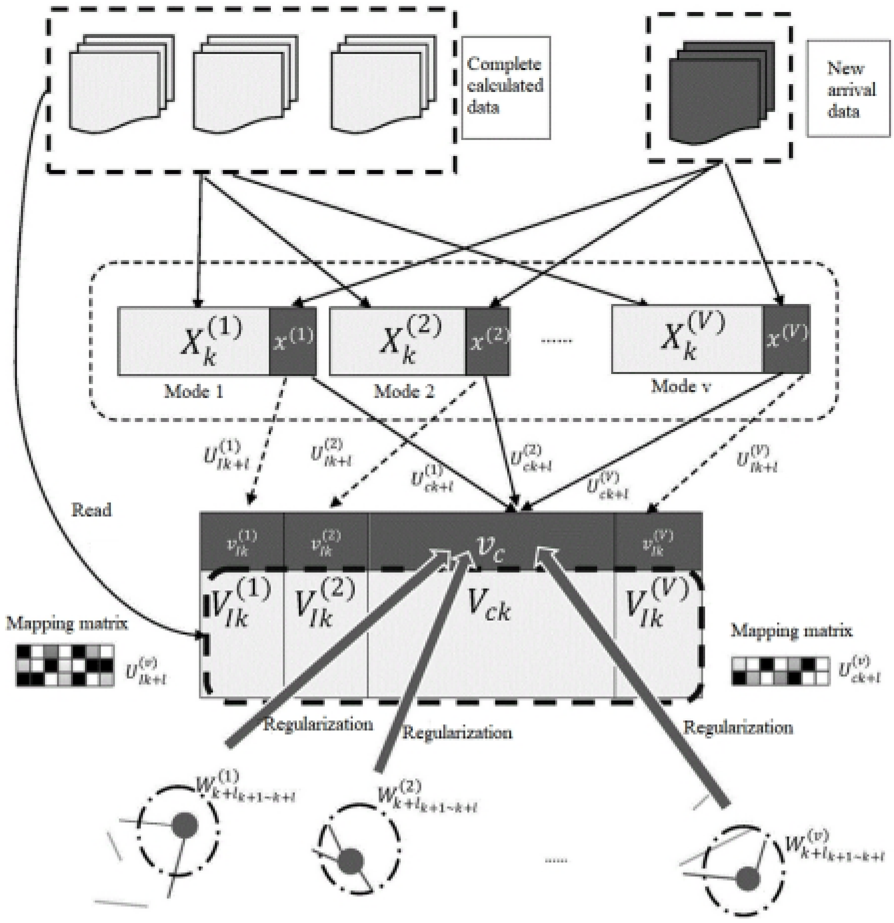

Figure. 3. Multi-modal CPG model

2.2. Stability of the multi-modal CPG model

Whether it is the movement of an animal or the movement of a biomimetic robot, it needs to be controlled by responsive joints. Of course, the most indispensable part of this process is to stabilize the joints.The snake-shaped machine has limbs different from other bionic robots, so this increases the complexity of the CPG model to a certain extent, and most of the relevant researchers only show the most basic stability of the snake-shaped machine. That is, they only proved the stability of a certain joint of the serpentine machine, which is theoretically incomplete.Based on the structural characteristics of the serpentine robot, this paper proves the stability of the multi-modal CPG model when the number of connections is random, which guarantees the theoretically smooth and stable performance of the system [5].

3. Methodology

The system structure of the snake robot trajectory tracking and dynamic obstacle avoidance algorithm based on deep learning is shown in Figure 4 [6].

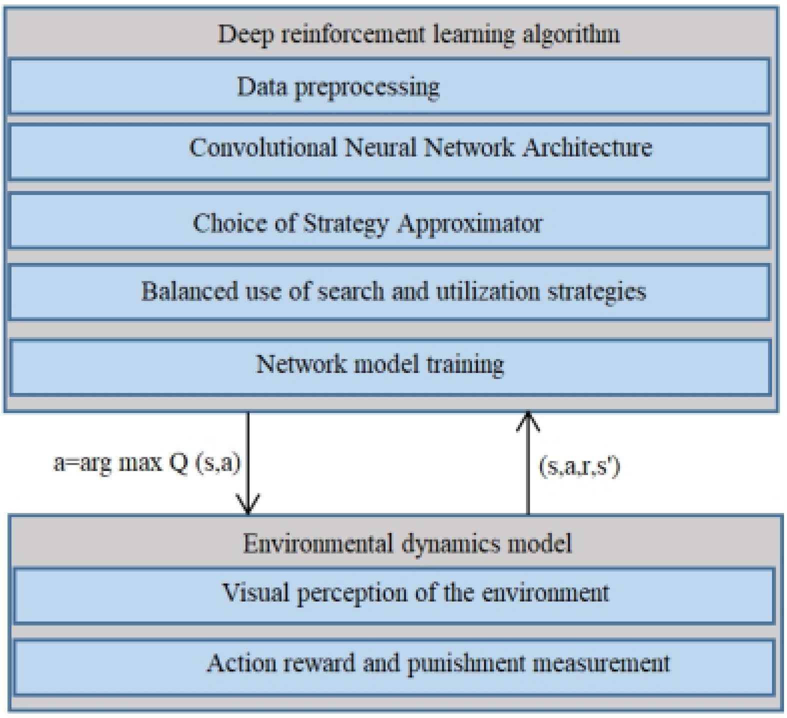

Figure. 4. Framework diagram of deep learning algorithm

3.1. Data preprocessing

When the snake-shaped robot obtains the motion trajectory and motion obstacle avoidance, it mainly uses the neural network to obtain the image data of the robot's perception. In this way, even if the image data becomes smaller, larger or displaced, the invariance of the position characteristics between the robot and the obstacle can be maintained.When the robot recognizes obstacles, it involves the study of the scene recognition system, as shown in Figure 5 is the organizational structure of the recognition system [7].

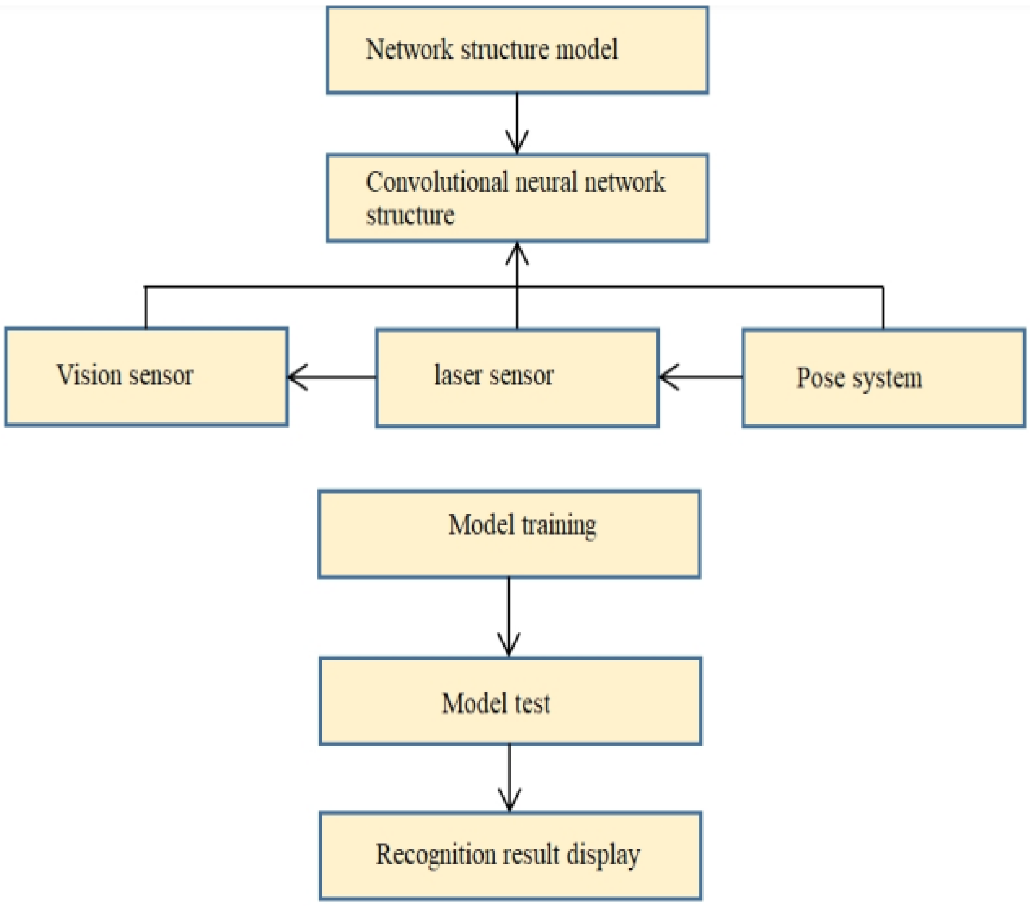

Figure. 5. Organizational structure of the recognition system

3.2. Strategy approximator selection

The approximator of the strategy chooses to use a deep convolutional neural network, and the optimization objective function of the model is formula (4) [8].

$$L(\theta) = E[r + y\,max_{a^{1}}Q(s^{'}, a|\theta) - Q(s, a|\theta)^{2})] \quad (4)$$

$$\Delta L(\theta) = E[r + y\,max_{a^{1}}Q(s^{'}, a|\theta) - Q(s, a|\theta))\Delta Q(s, a|\theta)] \quad (5)$$

The neural network model is shown in Figure 6

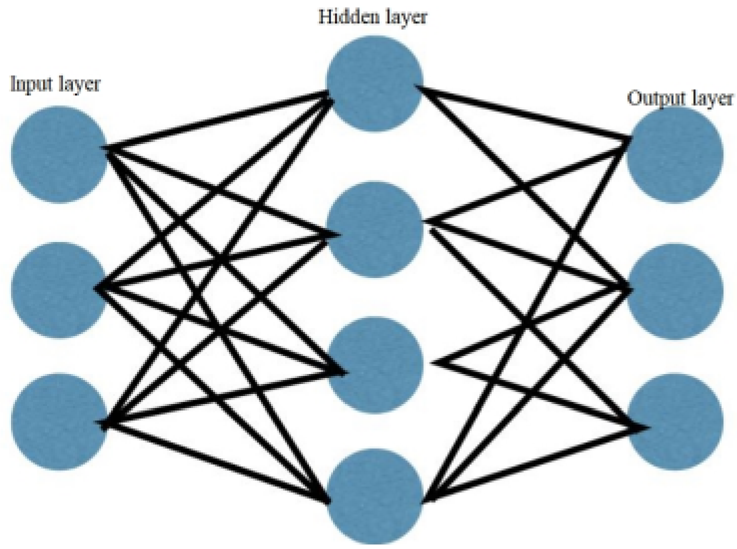

Figure. 6. Neural network model

3.3. Model training

When training a neural network, it is assumed that the training data is independent and evenly distributed, and there is a correlation between the data collected from the environment[9,10]. The network model training process is shown in Figure 7.

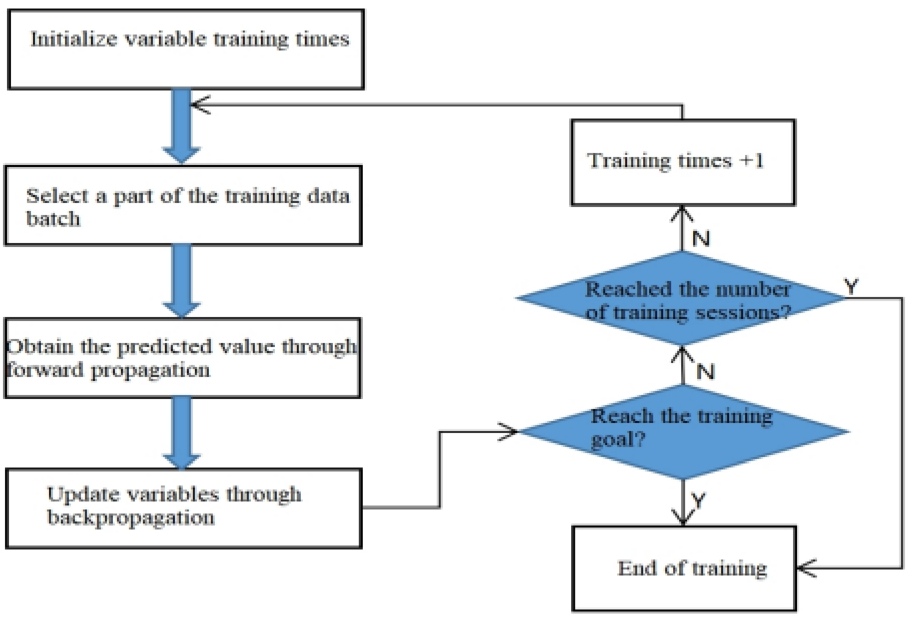

Figure. 7. Network model training process 6

4. Conclusion

With the advent of the era of artificial intelligence, robots based on various animal forms are constantly being produced.This paper mainly studies the environment adaptability and obstacle avoidance ability of snake-like robots.The snake-shaped robot uses a multi-modal CPG model to stably control the motion of the robot's body, and obtains the position information of obstacles through a neural network, and it will turn and avoid obstacles.At present, intelligent robots are still being researched and improved, and it is believed that intelligent robots will be more advanced in the future.

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