SUPERVISED GROWTH NETWORK SGWRN MODEL CAN ACHIEVE A BALANCED CONTROL OF TWO-WHEELED ROBOT

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ABSTRACT

Based on the unsupervised growth structure of the network GWRN model, GWRN model and radial basis function network architecture combined. Proposed supervised structure of the network can be grown SGWRN models. Model used is the growth of self-organized growth algorithm when needed, by inserting new neurons, changing the connection among competition layers and adjusting the connection weights between layers, achieve the required accuracy of the model output, simulation experiments show that, SGWRN model realizes the two balancing robot control, there are certain anti-interference ability and practicality.

Keywords: SGWRN model; Growth algorithm; Connection weights; Robot

1. INTRODUCTION

Self-organizing neural networks generally use unsupervised learning, each neuron model via inhibition of brain mechanism simulated human side since the distribution of the input mode of organizational learning , but also can learn the topology of the input vector. The development of the network can be grown based on the in self-organizing feature map network , the network according to their different requirements to adjust the size and structure of the network.. However, for a particular cyberspace mapping space, expected to produce a specific response to the unsupervised self-organizing neural network can be grown on some limitations, so need to establish a supervised network structure can be grown. This paper presents a supervised self-organizing network model can be grown, will be based on self-organizing network and RBF[1] network structure of the organic combination of growth, namely SGWRN model[2]. This model uses a network GWRN needed growth of self-organizing algorithm, hidden layer neuron growth and learning process involves the insertion of neurons, changing the connection between competition layer neurons and adjusting the connection weights among layers, model in the process of growth of self-learning, until the model output accuracy. SGWRN model is applied to balance control of two-wheeled balancing robot. The initial number of model neurons is less, hrough continuous learning, competitive layer neuron number is increasing gradually grown to be able to grasp the model of the robot balance control[3].

2. SUPERVISED CAN GROW SRLF-ORGANIZING NETWORK MODEL

Self-organizing neural network is usually unsupervised learning, generally they will enter the mapping data in an orderly manner to the low-dimensional topology, and could often be used to input data into subsets, so that the interior of a subset of data items is similar, and different subsets of data items are not similar. Based on the supervision of neuron growth structure, the unsupervised learning GWRN model extended to supervised learning can growth structure of neural network model, namely the proposed have supervision can grow SGWRN self-organizing network model.

Supervised growing structure network (SGWRN) model combined unsupervised growing network GWRN model with radial basis function (RBF) [4] . For the SGWRN model can learn under the guidance of the supervised signal, so the growth of network structure of GWRN model only two layer to three layer, its structure as shown in figure 1. The basic network structure by the Input Layer (Input Layer, IL), Competitive Layer (Competitive Layer, CL) and Output Layer, the Output Layer, OL) constitute the three Layer. Among them, the input layer and competition constitute GWRN model. Connection weight matrix between the input layer and competitive layer is W and Connection weight matrix between the competitive layer and output layer is V . Which the dimension of the input data and the number of neurons in input layer are the same, the dimensions of the output is the same as the number of neurons in the output layer, According to input data to adjust the number of neurons of the competitive layer, timely and growth, connection weights between the network layers will be adjusted in accordance with guidance of the supervised signal[5].

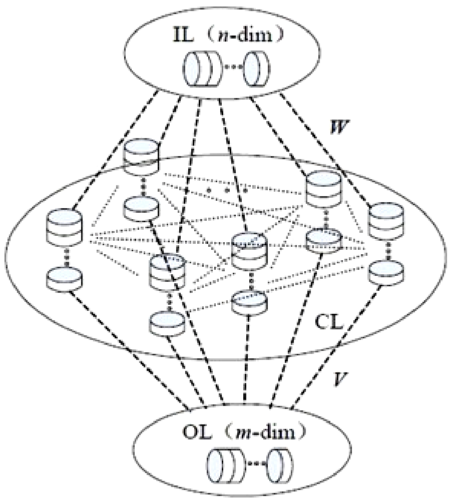

Fig1 SGWRN structure

SGWRN model algorithm consists of two parts, namely the network competitive layer neuron growth algorithm and the learning process of network under the supervised signal.

the growth and learning process of SGWRN model include that insert new neurons in the competitive layer, change the connections between neurons of the competitive layer and adjust the connection weight matrix W and V of the layer and layer, Network model learning in the process of adding neurons, until the output meet the precision requirement of the model[6].

First of all, the initialization supervised growing structure network. The initial competitive layer with 2 neurons, ie $K=\{n_1,n_2\}$ (K represents a collection of neurons mapping space); mapping space neuronal connections set C; using RBF as activation function of the neuron in the competitive layer, the threshold value b_1; number of neurons in the input layer and output layer are respectively n and m.

In best match neurons (BMU) s and the best match between neurons (SBMU) ss insert new neurons process is as follows:

1)Insert a new neurons r， $K=K\cup\{r\}$

2) to initialize the connection weights between new neurons r and the input stimulus ξ

$$\mathrm{w_r}=(w_r+\xi)/2 \tag{7}$$

3) remove the connection between s and ss

$$C=C/\{(s,ss)\} \tag{8}$$

4) Create a new connection between r and s, r and ss

$$C=C\cup\{(r,s),(r,ss)\} \tag{9}$$

If the sum of squared errors e can not reach the precision requirements, perform the following growing algorithm;

① Select the input / output data pairs （ξ,ξ）, calculate the Euclidean distance $\|\xi-w_i\|$ between competition layer neurons i and input vectors ξ.

② Select the best match of neurons and sub-optimal match to create a connection. Among them s and ss meet:

$$\|\xi-w_s\|=\min_{n\in A}\|\xi-w_n\| \tag{10}$$

$$\|\xi-w_{ss}\|=\min_{n\in A}\|\xi-w_n\| \tag{11}$$

③According to the following formula to adjust the best matching neurons s and the weights of the field neurons i.

$$\Delta w_s=\varepsilon_b\times h_s\times(\xi-w_s) \tag{12}$$

$$\Delta w_i=\varepsilon_n\times h_i\times(\xi-w_n) \tag{13}$$

Among them $0<\varepsilon_n<\varepsilon_b<1$， h_s and h_i meet:

$$h_s(t)=1-\frac{1}{\alpha_b}(1-e^{-\alpha_b t/\tau_b}) \tag{14}$$

$$h_t(t)=1-\frac{1}{\alpha_n}(1-e^{-\alpha_n t/\tau_n}) \tag{15}$$

④If the best matching neuron activation value a less than the activation threshold a_T, and the start count is less than the threshold h_T ,the network is growing(that is inserted new neurons r between s and ss).

Among them, $a=\exp(\|\xi-w_s\|)$；

⑤If there is available training samples, return①.

⑥ Numerical calculation competitive layer activation function of neurons i

$$d_i=\exp(-(\|w_i-\xi\|\cdot b_1)^2/2) \tag{16}$$

⑦ By (d_i,ζ) adjust v, and threshold of output layer neurons b_2

⑧ Calculate the output of the output layer

$$output=D\cdot V+b_2 \tag{17}$$

Calculate the error sum of squares e

⑨ If e arrived in accuracy, exit; Otherwise, insert new neurons, the network continue to grow.

3. SGWRN MODEL IS APPLIED TO TWO BALANCING ROBOT CONTROL

Supervised can grow self-organizing neural network model can be used in supervised learning. For balance control of two-wheeled balancing robot[7] [8], Corresponding to different states of the different time robots, If it can get the corresponding control quantity as monitoring signal, You can have a supervision can be growth dynamic structure model is applied to two wheel robot balance control. Based on supervised can grow structure of the neural network two rounds of balancing robot learning control system is shown in figure 2

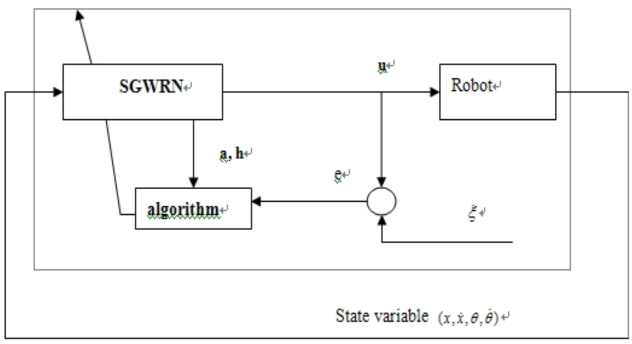

Figure 2 two wheel balance robot control model structure diagram

The dashed box is based on the growth structure of the neural network controller. The dynamic structure model for offline training, after training for two rounds of balancing robot for on-line control. Learning algorithm to obtain the activation values a of neurons from SGWRN and error sum of squares e. Dynamic structure model of the competitive layer consists of two neurons not connected at first, under the guidance of the learning algorithm, Dynamic structure model began to grow, continue to control the robot to learn the rules, until it meets the accuracy requirements. After training SGWRN as control output to control the robot[9] [10].

Here, robotic system for two rounds of balance, the state of the system is 4-dimensional vector, control of the robot's forces or its acceleration. Therefore, network model is established, the number of neurons in the input layer IL is 4, number of neurons in the output layer OL is 1, the initial number of neurons in the competitive layer is 2. Dynamic structure in the process of learning, the number of CL neurons incrementing, gradually grow into a master model robot balance control skills.

SGWRN algorithm flow:

1) Initialization: $A=\{n_1,n_2\}$, $C=\Phi$

2) CL neuron activation using RBF function, Thresholds b_1,

3) M linear output neurons

4) when the error sum of squares does not meet the accuracy requirement, Iteration λ times

① Select from a training set of input/output data (ξ,ς)

② Determine the BMU and SBMU, and establish a new connection C

③ By the formula, adjusting weight matrix W

④ When the network does not match the input stimuli, network growth and by the formula (7) calculated new neurons in the initial weights Calculated by the formula (7) new neurons in the initial weights, then equation (8), (9) to update the connection between neurons, the executive v; otherwise, direct execution

⑤ Calculate activation function value of CL neurons

$$d_i = \exp(-(\| w_i - \xi \| \bullet b_1)^2 / 2) \quad (18)$$

⑥ By (d_i,ς) adjust V, and OL neuron threshold value 2

⑦ Calculate OL output

$$output = D \bullet V + b_2 \quad (19)$$

⑧If e meet the accuracy requirements, exit the loop, otherwise, add a new neurons, the network continues to grow.

4. SIMULATION EXPERIMENT

SGWRN model can be applied to solve the problem of balance control, SGWRN in to a certain degree of offline learning control law, Control can be performed online.

In two rounds of the balancing of the robot control as an example, design a dynamic structure model learning model, and apply the model to control.

Sample vector is expressed as $(x,\dot{x},\theta,\dot{\theta},\varsigma)=(0,0,5pi/180,0)$,randomly selected 50 samples for study. Set parameters of SGWRN were $\varepsilon_b=0.6$, $\varepsilon_n=0.25$, $\alpha_b=0.8$, $\tau_b=5$, $\alpha_n=1.3$, $\tau_n=13$, $h_T=0.38$, $\alpha_T=0.6$. The sampling period is $T=0.01$,requires e less than $1.25e-12$,Training CL neurons number is 60 SGWRN model are obtained.

The initial set up tilt angle is 5 degrees, the initial position is zero, with training of supervision to control the robot dynamic structure model, and comparing with no supervision and control the robot dynamic structure model. In the process of the control ,acting on the robot control, no supervision and dynamic structure model output as shown in figure 3, supervised the dynamic structure model output as shown in figure 4, the horizontal axis shows the sampling points.

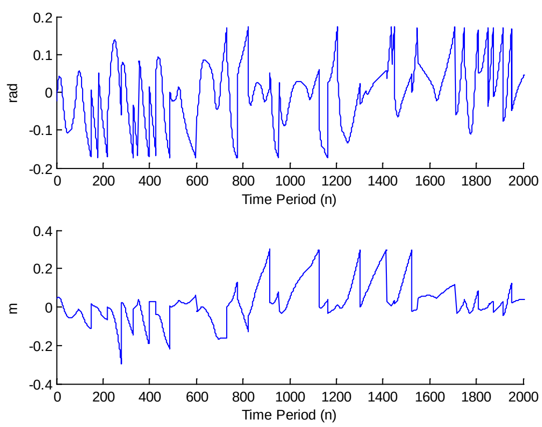

Figure 3 GWRN model control the robot state

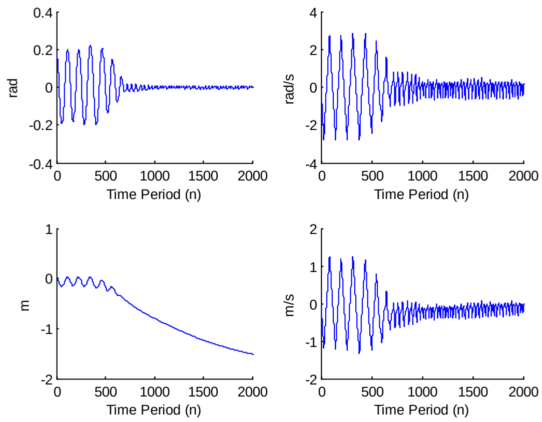

Figure 4 SGWRN model of state control of the robot

Corresponding to each time the state of the robot (the location of the car and tilt Angle) as shown in figure 4, the robot's state variables, fast convergence SGWRN model control effect is good

Through the simulation experiment shows that, Figure 3 unsupervised learning network model can't very good control Angle and displacement of the robot, The figure 4 state variables of the dynamic structure model can in good control. Two figure in comparison, It is concluded that the proposed dynamic structure model has good practicability, shorten the time to learn, verify the validity of the model.

5. CONCLUSION

This paper presents a supervised structure of the network can be grown (SGWRN) model, the model combined no supervision can grow network with RBF function, to achieve balance control two-wheeled robot. Growth dynamic structure in monitoring network signal rapidly under the guidance of learning, increasing competition layer neurons, then the network model in offline training, after training is good for two rounds of robot via online balance control. The network model effectively solves the mapping space for a particular network, expected to produce a specific response. The Simulation results show that, a dynamic structure model with no supervision structure model is compared, Supervised more dynamic structure model can be finished in a short time the balance control of the robot, and when two rounds of the robot parameters change too much , still can well control the balance of the two rounds of the robot. Shows the monitoring dynamic structure can better achieve the equilibrium of two rounds of balance control of the robot, practical.

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