Investigation of Steering Parameters using Artificial Neural Network Simulation

Pramod Belkhode
Assistant Professor
LIT, Nagpur

ABSTRACT
The suspension basically comprises of a linkage which is a 3D mechanism SRRS (Spherical, Revolute, Revolute, Spherical). On the basis of six included angles of this four bar chain, position of kingpin axis is determined. Once the position of kingpin axis is decided corresponding steering parameters can be determined. In such complex phenomenon involving non-linear kinematics where validation of experimental data based models is not in close proximity, it becomes necessary to formulate Artificial Neural Network (ANN) Simulation of the observed data. The paper detailed about the steering geometry and formulation of Artificial Neural Network (ANN) simulation.

Keywords
Camber Angle, Caster Angle, Kingpin Angle, Steering Geometry, ANN

1. INTRODUCTION
A front Suspension basically comprises of a linkage which is a 3D four bar chain mechanism SRRS (Spherical, Revolute, Revolute, Spherical) as shown in fig 1. The important element of a steering system consists of linkages and geometry associated with the steer rotation axis at the road wheel. This geometry effect the overall performance of vehicle. The digital computer simulation for estimating the caster angle and kingpin angle is derived in this paper. Once the position of kingpin axis located that two end coordinates of the kingpin axis. Using Matlab - Program kingpin angle and caster angle is estimated. Kingpin angle determine the dynamic behavior of the vehicle. So estimation of these angle diagnoses the vehicle behavior.

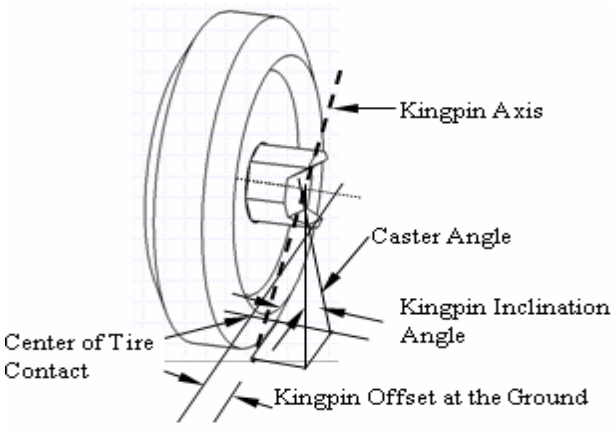


Fig 1 : The A arm front suspension

2. STEERING PARAMETERS
- Kingpin axis*:*

The steer angle is achieved by rotation of the wheel about a steer rotation axis. This axis is kingpin axis is shown in figure.
- Kingpin inclination angle:

The angle in front elevation between the steering axis and the vertical.
- Caster angle:

The angle in side elevation between the steering axis and the vertical.
- Camber angle:

The Inclination of the wheel plane to the vertical

3. COMPUTER SIMULATION
3.1 Artificial Neural Network
Artificial neural network is an information processing pattern or methodology. Neural Network is used to learn patterns and relationship in data. To generate model that perform a sales forecast, a neural network needs to be given only raw data related to the problem. The raw data might consist of history of past sales, Prices, Competitor's prices' Other economic variables.

The neural network sorts through this information and produces an understanding of the factors impacting sales. The model can than be called upon to provide a prediction of future sales given a free cost of the key factors.

This advancements are due to the creation of neural network learning rules, which are the algorithms used to learn the relationship in data. The learning rules able the network to gain knowledge from available data and apply that knowledge to assist a manager in making key decision.

The development of ANN started 50 years ago. ANN are gross simplification of relationship of neurons. The methodology of neural network which began during the 1940's promises to be a very important tool for studying the structure function relationship of the human brain. Artificial neural network consists of many nodes i.e processing unit analogs to neuron in the brain.Each node has a node function associated with it which along with a set of local parameters determines the output of the nodes, given an input .The signals are transmitted by means of connection links. The links posses are associated weight, which is multiplied along with the incoming signal (net Input) for any typical neural net. The output signal is obtained by applying activation to the net input.

The experimental data based modeling has been achieved based on experimental data for the seven dependent pi terms. Simulation consists of three layers. First layer is known as input layer. No. of neurons in input layer is equal to the no. of independent variables. Second layer is known as hidden layer. It consists of seven number of neurons. The third layer is output layer. It contains one neuron as one of dependent variables at a time. Multilayer feed forward topology is

decided for the network. MATLAB software is selected for developing ANN simulation**.**

3.2 Association of Biological Net with Artificial Net

Biological Neurons : The basic building block of the brain are slower than silicon logic gates

Biological Neurons operates in milliseconds slower than the silicon gates operating in the nanosecond range because

a. Huge no. of nerve cell

b. Function of biological network seems to be much more complex than the logic gates

The brain is a very energy efficient. It consumes only about 10 – 16 joules / operation / second comparing with 10 – 6 joules / operation / second for a digital computer.

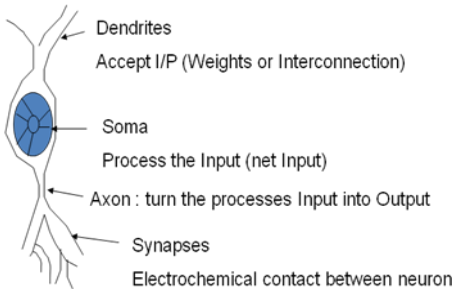


Fig 2 : Biological Net

3.3 Procedure for ANN

The various steps followed in developing the algorithm to form ANN are as under.

1. The observed data from the experimentation is separated into two parts viz. input data or the data of independent pi terms and the output data or the data of dependent pi terms. The input data and output data are imported to the program respectively.

2. The input and output data is read by prestd function and appropriately sized.

3. In preprocessing step the input and output data is normalized using mean and standard deviation.

4. Looking at the pattern of the data, feed forward back propagation type neural network is chosen.

6. This network is then trained using the training data. The computation errors in the actual and target data are computed and then the network is simulated.

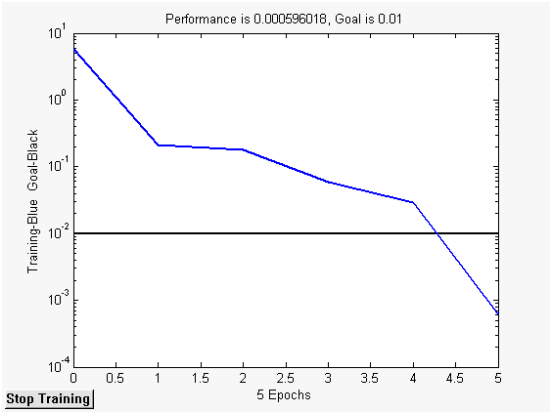
4. ANN PROGRAM

Artificial Neural Network Program for determining the steering Parameters

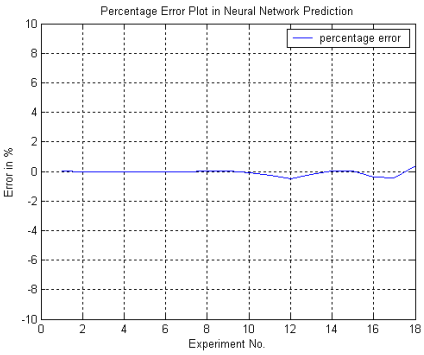
```
clear all;
close all;
inputs=[ ]
input_data=a2;
 output=[ ]
size(a2);
size(y2);
p=a2';
sizep=size(p);
t=y2';
sizet=size(t);
[S Q]=size(t)
[pn,meanp,stdp,tn,meant,stdt] = prestd(pn,tn);
 net = newff(minmax(pn),[n 1],{'logsig' 'purelin'},'trainlm');
 net.performFcn='mse';
net.trainparam.goal=.01;
net.trainparam.show=200;
net.trainparam.epochs=50;
net.trainparam.mc=0.05;
net = train(net,pn,tn);
an = sim(net,pn);
[a] = poststd(an,meant,stdt);
error=t-a;
plot(x1,t,'rs-',x1,a,'b-')
legend('Experimental','Neural');
title('Output (Red) and Neural Network Prediction (Blue) Plot');
xlabel('Experiment No.');
ylabel('Output');
grid on;
figure
error_percentage=100*error./t
legend('percentage error');
title('Percentage Error Plot in Neural Network Prediction');
xlabel('Experiment No.');
ylabel('Error in %');
grid on;
figure;
plot(x1,yy_practical_abs,'r-',x1,yy_eqn_abs,'b-',x1,yy_neur_abs,'k-');
legend('Practical','Neural');
title('Comparision between practical data, equation based data and neural based data');
xlabel('Experimental');
grid on;
```

5. NUREAL NETWORK PREDICTION

Neural network prediction for the steering parameter kingpin angle is shown in figure 3.



Training of the Network for Kingpin angle



Percentage error plot prediction for the network for kingpin angle

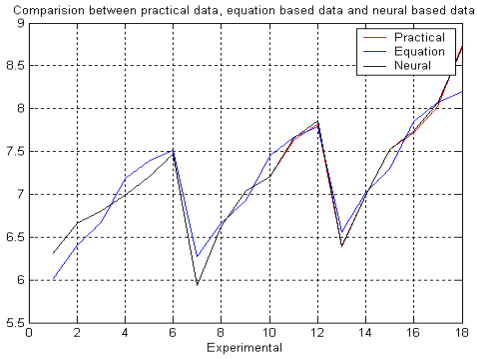


Fig 3: Graph of neural network prediction

6. ANN MODEL

The capability of the ANN model is to generalize unseen data dependent on several factors. These factors are appropriate selection of input output parameters, the distribution of the input and output dataset and the format of the presentation of the dataset to the neural network. Selected input parameters are the significant variables that affect the steering parameters. The input parameter include Length of Upper control arm, Length of Lower control arm, Length of Knuckle arm, Length of Fixed link, Diameter of wheel, Mass of wheel, Road surface roughness in terms of Braker Height , Road surface roughness in terms of Braker Width, Wheel linear velocity, Operational time, Acceleration due to gravity, Clearance at spherical joint A, Clearance at spherical joint B, Clearance at revolute joint O1Clearance at revolute joint O2, Lateral displacement, Spindle length. The output parameters of the model is then Kingpin angle, Camber angle, Caster angle, Toe angle, Toe in, Toe out, Scrub radius.

6. ACKNOWLEDGMENTS

I thanks to the Dr. J. P. Modak, for helping me to study the topic ANN. He has contributed towards development of the ANN Program.

7. REFERENCES

[1] K.S. Fu, R.C.Gonzalez, C.C.G.Lee, “Robotics: Control, Sensing, Vision and Intelligence”, Mc graw hill Internation Edition, Signapore.

[2] S. N. Sivanandam, S. Sumathi, S.N.Deepa, “Introduction to Neural Networks using Matalb 6.0”, Publication: Tata Mcgraw-Hill Publishing Company Limited, New Delhi

[3] Stamatios V. Kartalopoulos, “Understanding Neural Networks and fuzzy Logic – Basic Concepts and Applications ”, Publication Prentice Hall of India Private Limited, New Delhi, 2004.

[4] H Sharek. Jr., “Theory of Engineering Experimentation”, Mc Graw Hill, 1961, First Edition.

[5] Dr. Kirpal Singh, “Automobile Engineering”, Vol I, 9 th Edition, 2003, Standard Publishers Distributors, Delhi – 110006.

[6] K K Ramalingam, “Automobile Engineering ” - Theory and Practice, Second Edition, Scitech Publications (India) Pvt. Ltd. Chennai – 600027.

[7] J. Meissonnier, J.c. fauroux, G. Gogu, C. Montezin, “ Geometric identification of a car suspension mechanism based on part displacement analysis ”, 12th IFToMM World congress, Besancon (France), June 18-21, 2007