Speed Estimation Of Induction Machines Based On Current And Voltage Waveform Made By Artificial Neural Network

Antoni Nykliński Michał Rad

***Abstract* — the paper presents research of application Neural Network in computations based on raw, time-domain signals. In this study the speed value of the induction motors was estimated from current and voltage values. The standard backpropagation model of nonlinear Network was used with some method of recurrence proposed to obtain dynamic capability of the Net.**

Current and voltage values that are given to the network inputs, can be obtained much easier then speed signal. Therefore method described in the paper could be useful to obtain speed value without exact speed measurement.

Reliable speed signal could be also useful to determine a motor torque that is even more difficult to measure. Considering this, we start searching network which can determine motor speed and in the future motor torque.

Finally, article describes preparing all data sets for training and testing and also shows some results of testing on real machines.

I. Introduction

This paper describes investigation of using neural network as some kind of induction machine model. We are trying to get speed signal on output, putting values of current and past values of speed at input. First of all we try to check if simple backpropagation model of neural network can manage this task. There are many papers showing that nonlinear neural network can imitate any (even nonlinear) functions. This examination checks it in practice.

II. Realization

A. Working scheme

Fig. 1 shows how this system should work. At the input we are putting 70 discrete values of a current, 70 discrete values of a voltage and 6 past values of speed. Neural network calculates an answer which is a

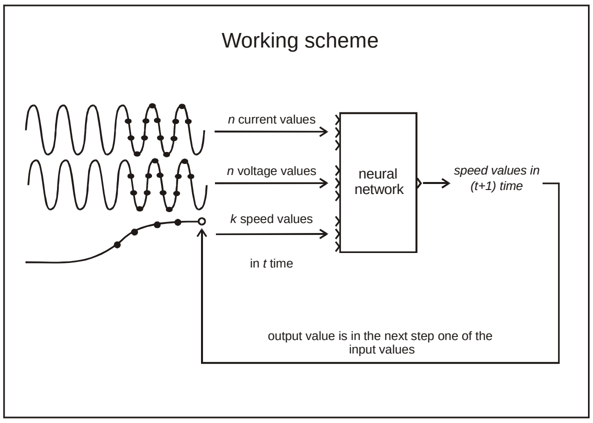

Fig. 1. Working scheme

speed value of this moment. In the training time this value is compared with real value and network is trained according to backpropagation algorithm. In a "working time" values of the output are saved and given to the input (in right sequence). So in the first step of working we have to put a few "starting" values to run this system and then it will continue with speed estimation.

Training set contains data from three full starting time (time from speed zero to maximal speed). From each starting time we get many training vectors. The training vector (as described above) contains values of a current, voltage, and speed in a certain period. These periods are overlaying partially each other.

B. Problems and Solutions

During the investigation, even after getting first discussible results we encounter some problems. First we notice that speed approximation is poor near the zero and near the maximum speed. In this time the output values of network were scaled from 0 – speed zero, to 1 as maximal speed (1500). Activation function was sigmoidal and (as we know) could get values from 0 to 1 range, but can not reach 0 either 1. To improve this we have changed the range to (0.2 – 0.8) and got much better results.

To start this system we should apply a few starting values of speed (as wrote above). Because of this, it would be very good to start from zero speed.

The authors are with Katedra Maszyn Elektrycznych AGH Kraków
e-mail: anyk@uci.agh.edu.pl rad@uci.agh.edu.pl tel (012) 617-40-16

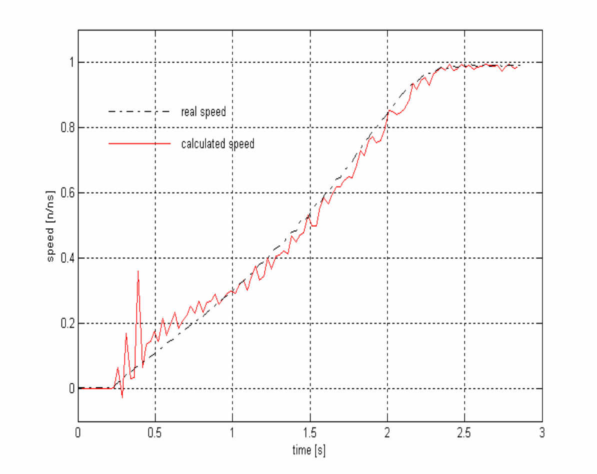

Fig. 2. Noise in the starting moment.

In a real case, during the starting moment (connection of voltage), some noise often appears. At this moment the output from the net was very rugged. To avoid this, we decided to include in the training set more then three starting moments (training sets consists of training vectors made from three full staring time so normally there are three starting moments). This improves the process greatly.

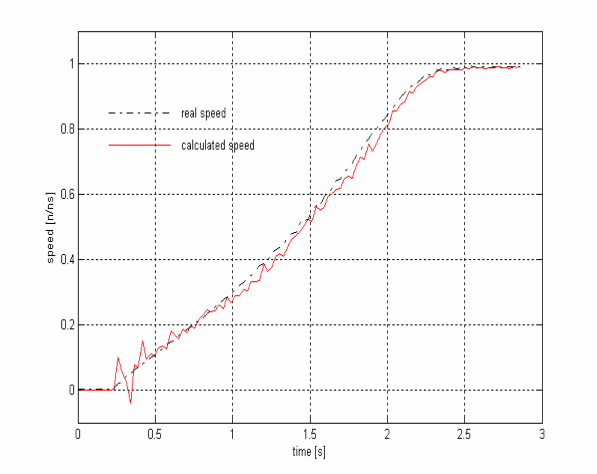

Fig. 3. Starting noise is reduced.

C. Calculations Aspects

All calculations were made in the Matlab, the neural network is implemented in our own Matlab application. Files containing the training set are rather big and it was only one inconvenience. Training time was acceptable (on 800 MHz Duron it was only few minutes) and "working" time (time of speed approximation) is not longer original starting time (in examined machines is a few seconds). So, let us suspect that the system could work in a 'real time' applications.

D. Final Results

We have examined two induction machines: squirrel cage motor and slip ring motor. Investigations contained only starting time of these machines.

We used a separate data to train and separate data to check the system. Final results are positive (Fig 3).

For a slip ring motor we were able to check what has happened if the rotor resistance is changed (this changes torque versus speed characteristic) and we can see it on (fig 4). This means that our neural model works good only for 'known' machines (machines which data contains a training set).

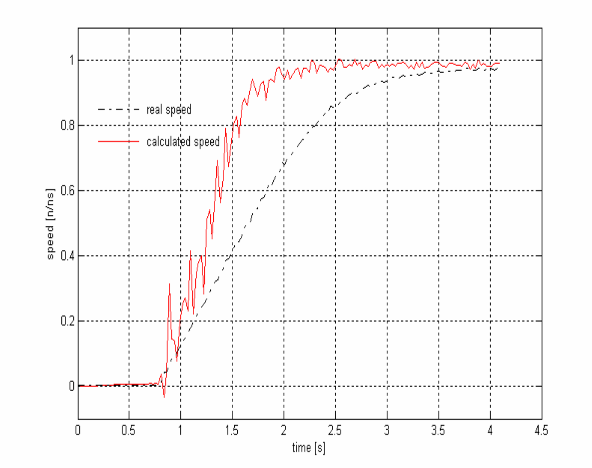

Fig. 4. Results of net for trained for other machine.

Several configurations of the network were tested and results were quite the same for networks with two hidden layers and for these with one hidden layer and with enough neurons (about more then 20).

III. Conclusion

As result our investigation might not have an implicit practical application, but it would be worth to consider further research on such system ability.

References

[1] J. Korbicz, J. M. Kościelny, Z. Kowalczuk, W Cholewa, "Diagnostyka Procesów, modele, metody sztucznej inteligencji, zastosowania", WNT Warszawa, 2002.
[2] R. Tadeusiewicz, "Sieci neuronowe", Warszawa 1993