16th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2012, Dubai, UAE, 10-12 September 2012

ANALYSIS OF TRACTOR TRACTION FORCE WITH ARTIFICIAL NEUROL NETWORKS IN CULTIVATION

Alper Altınışık
GETRAG Innovations Center,
Hermann- Hagenmeyer- Strasse,
Stutgard,
Germany

Hakan Terzioğlu
Selcuk University Faculty of Technology,
epartment of Mechanical Engineering,Konya
Turkey

Hacı Sağlam
Selcuk University Faculty of Technology,
Department of Mechanical Engineering,Konya
Turkey

Kemal Altınışık
Selcuk University Engineering Faculty
Department of Mechanical Engineering,Konya
Turkey

ABSTRACT
Fast advancements in agricultural machinery as a result of scientific and technological development have led to socio-economic and cultural improvements in rural areas. This is particularly the case in countries with limited agricultural areas as these countries have to adapt to advance agricultural technologies in order to achieve optimum yields. That's why it is necessary to improve the efficiencies and effectiveness of the agricultural mechanizations. Tractors are among the agricultural machines that play an important role in the sector. This is so because tractors are not only the hauling equipment in the agricultural fields but can also be involved in a number of tasks in the sector. In this study, a computer controlled testing system has been established and an artificial neural networks (ANN) was used to analyze a tractor's traction force in soil processing. With this aim, three different ANN models (Model-1, Model-2 and Model-3) were established. Input and output layers for each model were selected and, for given operating speeds and work depths, the data obtained from empirical analysis and those from the ANN measurements were calculated. In order to find the most appropriate model among the three selected ANN models, a cross- validation test was applied to the ANN results by taking the test data into consideration. From the results, it was found that Model-1 is the best selection. By applying the cross evaluation to the ANN test results, this study has shown that, in agricultural mechanization, it is possible to predict tractor's speed and soil processing depth based on the soil properties.
Keywords: computer controlled test system, measurement tractor traction force, artificial Neural Networks, cross-validation

1.INTRODUCTION
There are various measurement systems developed for determining fundamental management data and making a mechanization plan in agricultural mechanization. There are also many studies in literature which are related to the analysis of the field test data obtained with Artificial Neural Networks (ANN) by establishing a computer controlled, intelligent test system in agricultural mechanization. However, in accordance with the pre-determined parameters of tractor's speed and soil processing depth in

agricultural mechanization, the studies which show the estimation of fundamental management data will be possible, are known to be very limited.
Zos [1] identified the variables affecting tractor field work capacity and explained the estimation methods of tractor drawbar capacity. In this method, he estimated the variables of drawbar force, drawbar power, operating speed and wheel slip by a means of a graphical cart.
Lyne and Meining [2] explained the design characteristics of the wheel slip measurement set and the calibration characteristics of the set. They used photo-electricity detectors in this study for measuring the wheel slip and operating speed. Signals which were taken as analog values, were recorded on data processing device after analog digital transformation.
Clearence and Voorhees [3] developed a drawbar dynamometer which measured horizontal and vertical forces independently and spontaneously on three-point hitch of a tractor. They measured horizontal and vertical forces with the extended wires installed on horizontal shaft available on linkage roof of the measurement system.
Kendal et al. [4] created a drawbar dynamometer of three-point hitch mechanism. They gave information about linkage roof, design of measurement sytem, force detectors, detection conditions and force estimation model and calibration characteristics in their studies.

2. EXPERIMENTAL STUDY

Soil in any field is similar to soils in the other field, there may be parts having different properties in the same field. Generally, these differences are color, slope, height, depth, product difference, variety for fertilization and tillage. This study was conducted on the field of agricultural experiment at Agricultural Faculty in Selcuk University. The experiemntal field included light soil, depth of 0-300 mm, soil structure of 24 µm clay, 26 µm silt and 50 µm sand. The class of soil was sandy-loamy soil. The study was done in April and September in 2009 and 2010. The average heat value was 28,8 ^{o}C and the relative moisture rate was 54,1 % in April, and also, these values were 26,7 ^{o}C and 52,8 % in September. The working width of mouldboard plough used in agricultural machine was 750 mm and its body made up of two parts. The STEYR 8073-70 tractor was used as an agricultural machine. The computer-aided measurement system was installed into the tractor and the equipments were attached to the tractor with the three-point hitch. Six Load cells were fixed for the measurement of forces. Signals getting from the load cells were recorded on a computer for every 10 seconds.
Due to the movement of the tractor in experimental field, the penetration values and the bulk density of compacted soil changed. These values increased in every passing of the tractor. The utmost need of drawbar force in field works is seen in tillage equipments. In this study, drawbar force, wheel slip, drawbar power and fuel consumption were measured among fundamental management data in accordance with different operating speeds of a tractor and work depth in tillage system.

3.ARTIFICIAL NEURAL NETWORK MODEL

By changing the input and output parameters in the study, three different models of Artificial Neural Network were established. The same training system was applied for three models and the system model of 10 interlayers for each model was designed. The training rate was selected as 0,05 for back propagation algorithm. 10^{-4} error value was determined as output criteria.
Version depth and operating speed were taken as input parameters at Model 1. Drawbar force, total drawbar force, wheel slip, drawbar power and fuel consumption were selected as output parameters (*Figure 1*).

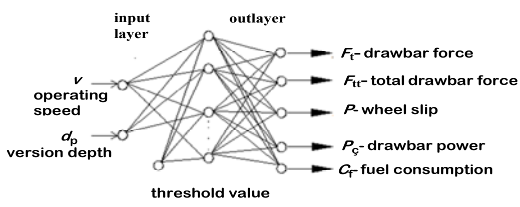


Figure 1. ANN Model 1

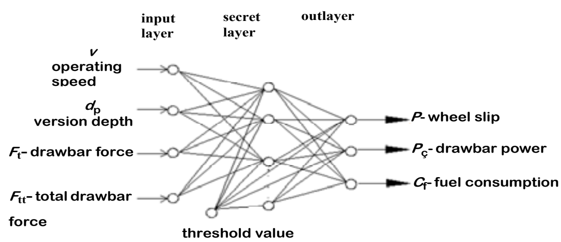


Figure 2. ANN Model 2

In Model 2, operating speed, version depth, drawbar force and total drawbar force as input parameters, and wheel slip, drawbar power and fuel consumption as output parameters were taken *(Figure 2).*

In model 3, operating speed, version depth and total drawbar force were used as input parameters, and wheel slip, drawbar power and fuel consumption were selected as output parameters *(Figure 3).*

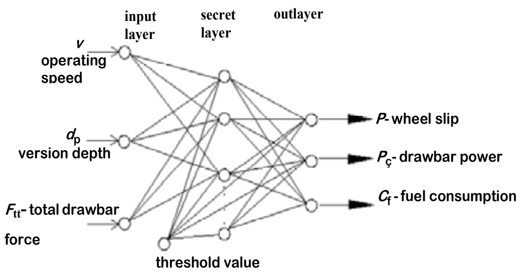


Figure 3. ANN Model 3

As seen in Figure 1, 2 and 3, wheel slip, drawbar power and fuel consumption were shared by three developed models. According to the number of experiments, wheel slip, drawbar power and fuel consumption for each model were compared in *Figure 4. a, b and c.*

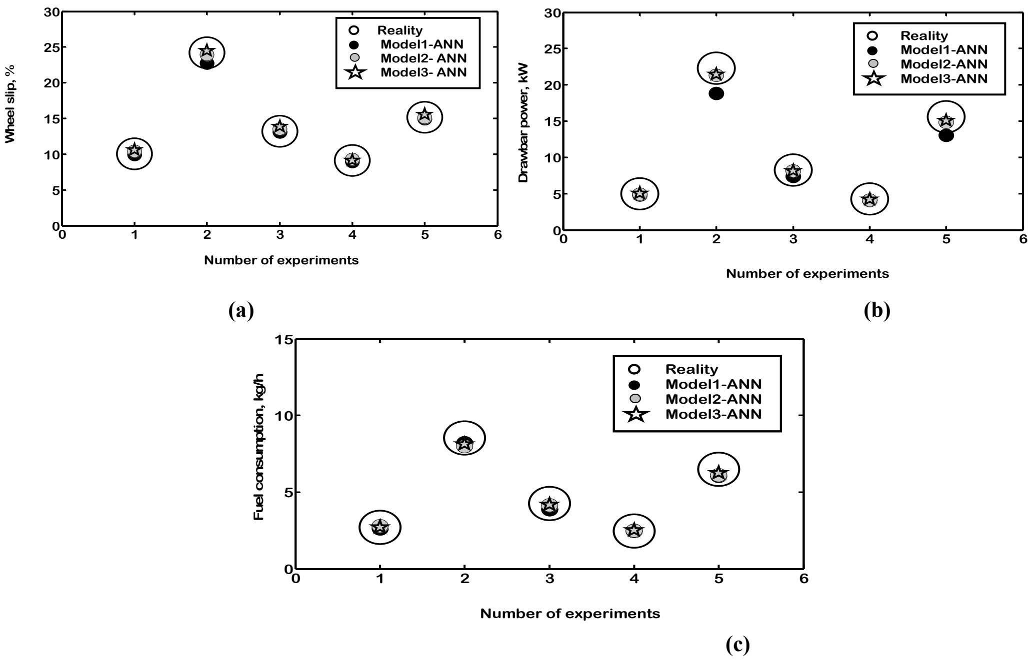
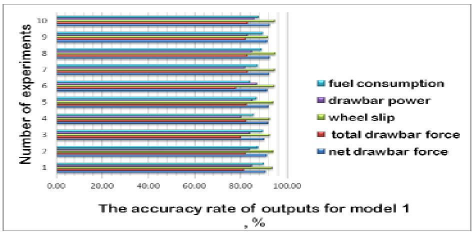


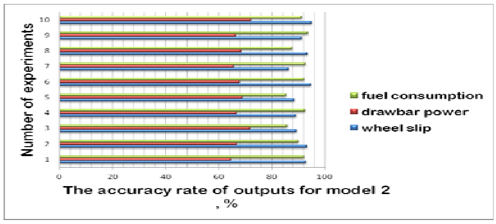
Figure 4. a, b and c, According to the number of experiments, wheel slip, drawbar power and fuel consumption for Model 1, Model 2 and Model 3

4. CROSS-VALIDATION

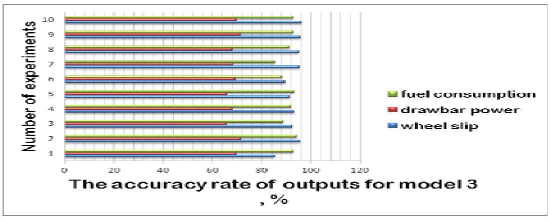
In the experimental study, a data set of 21 samples was used. In the experiments done with the method of cross-validation, 4-fold cross-validation was applied for the data set. The data set was divided into four groups consisting of 5, 5, 5 and 6 samples. 4-Fold cross-validation was applied for 3 different ANN models designed seperately and the success rate was found on average. These processes were done 10 times in total, and the average of 10 processes was accepted to be the success rate. The accuracy rates of outputs corresponding to inputs with cross-validation method for Model 1, Model 2 and Model 3 were shown in *Figure 5, a, b and c.*



(a)



(b)



(c)

Figure 5. The accuracy rates of outputs with cross-validation for Model 1 (a), the accuracy rates of outputs with cross-validation for Model 2 (b), and the accuracy rates of outputs with cross-validation for Model 3 (c)

5. RESULT AND DISCUSSION

The primary aim of this study was to find a match in field version rapidness and equipment processing depth depending on soil type. 3 different ANN models were designed in this study. Output parameters were found by changing input parameters for each model. In order to evaluate the suitability of designed models, the cross-validation test was applied. The accuracy rate of output parameters at Model 1 was 90% on average, the selection of designed Model 1 was taken as a correct evaluation. By using cross-validation for ANN test data, this study concluded that it was possible to estimate fundamental management data at high accuracy in accordance with pre-determined tractor speed and work depth.

6. REFERENCES

[1] Zoz, F.M., 1972, Predicting Tractor Field Performance, *Transactions of the ASAE*, 249-255.

[2] Lyne, P.W., Meiring, P., 1977, A Wheel Slip Meter For Traction Studies, *Transactions of the ASAE*, 238-240.

[3] Clearence, E. J., Voorhees, W.B., 1979, A Force Dynamometer For Threee Point Hitches Transactions of the ASAE, 226-232.

[4] Kendal, C.K., Nachtigal, C.L., Dooley, J.H., 1984, Three Point Hitch Dynamometer Data Acquisition System, Winter Meeting of The ASAE, ASAE Paper, 84-1596, St. Joseph, 49085-9659.