Hydrol. Earth Syst. Sci. Discuss., 4, S1242–S1248, 2007
www.hydrol-earth-syst-sci-discuss.net/4/S1242/2007/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Prediction of littoral drift with artificial neural networks" *by* A. K. Singh et al.

A. K. Singh et al.

Received and published: 19 October 2007

Authors’ replies to the referees’ comments

Referee #1

1. Section 2.2 - did you collect the data at regular intervals across the 4 month period? More information about the data collection process is required.

Section 2.2 modified as given below:

The network was trained with the help of field observations. The location belonged to a four-km stretch of the coast off Karwar along the western coast of India. These field measurements were done daily from 5 February 1990 to 31 May 1990 by the National Institute of Oceanography at Goa, India. The sediment load was measured along a cross section of the surf zone at six stations at the same time and at a number of points vertically at each station. In each day, the traps were deployed for 6 hours during 0700 to 1300 hrs and the average sediment load per hour was calculated. Two different traps were used to measure the littoral drift rates. Mesh traps having circular openings were used for measuring the suspended load transport and streamer traps were used for measuring the bed-load transport. The opening of the trap was 0.2 m wide, 0.15 m high, and rectangular in shape. The filter cloth mesh opening size was 90 μm and the opening of the mesh trap was 0.034 m. The measurements of the significant wave height and average zero cross wave period along with the wave direction corresponding to the spectral peak were made with the help of a WAVEC buoy. The breaking wave height and corresponding angle were derived as per the procedure in Skovgaard et al. (1975) and Weishar and Byrne (1978) and also visually confirmed. The width of the surf zone was measured daily using a graduated rope. The average longshore currents were measured daily (in terms of the distance covered in two minutes) using the Rhodanine-B type dye injected at the trap locations. The suspended load was collected by mesh traps with circular openings and the bed load was gathered by streamer traps. The procedure of Kraus (1987) was used to determine the total sediment transport and this was based on the trapezoidal rule. A standard sieve analysis gave the median size distribution. When all the parameters such as wave height, wave period, wave direction, longshore current speed and direction and sediment load at different trap locations along the surf zone, were not collected in a day due to malfunctioning of instruments or due to overtopping of traps, then the data of that day were not used in the analysis. The details on the data collection and the estimation of measured sediment load are presented in Kumar et al. (2003). The tides were predominantly semi-diurnal with an average spring tide of 2 m and neap tide of 0.25 m during the measurement period. The longshore current velocities were measured at the trap locations. The velocity varied from 0.1 m/s to 0.6 m/s with an average value of 0.3 m/s. Table 1 shows ranges of the significant wave height, average zero cross wave period, breaking wave height, breaking angle, surf zone width as well as rate of the drift along with their mean values and standard deviations involved during

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the training and testing excercises.

2. Section 2.3 - With such a small data set, you need to repeat the NN experiments several times with different random selections of your 75/25 split. This is the one major change that I suggest you make so that you can ensure your results are valid.

This has been already done. In one such split we did not get good training and testing results and hence random selections of the training and testing pairs were done innumerable number of times till we finally converged upon the one that produced the best outcome in terms of the error statistics. This is now added in the revised text. (section 2, end of page 6).

3. Section 2.3 - what learning algorithm resulted in the best performance? This should be linked to comment 2 above, i.e. did you find consistency in the learning algorithm when trying out further modelling experiments.

The algorithm of CGB resulted in the best performance. This scheme of training achieves its efficiency using minimum orthogonality between the current and the preceding error gradient. The CGB algorithm performed consistently well for almost all trials. The above is now added in the revised text. (Section 2, page 7)

4. Section 4 - more explanation is needed of the extended two stage network. Is the extension learning the errors of the first network?

The two networks were trained independently. The first network was supposed to have done major regression while the second network (in a different form) used the errors produced by the first network to obtain the desired output. This is now added in the text in section 10, just before section 5.

Editorial comments The paper is well written. Just two small changes: 1. Introduction - change to ’better alternative to statistical methods’

Done.

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2. Conclusions - change to ’less accuracy than the ANN’.

Done.

Referee #2

1. The number of data points used in the study is limited (circa 61 in training and 20 in testing). The complexity of the ANN model is too high for the limited available data. Determining the unknown weights for a 5-6-1 ANN model with 61 training data points to provide a generalization capacity of the ANN seems to be ambitious. The authors have made the ANN model more complex by having another ANN model. With the introduction of another ANN model the number of unknown weights increases. Some references on ANN may be useful (eg Haykin, 1999).

For the 5 x 6 x 1 network the number of unknowns are (36 weights + 7 bias =) 43 and this is less than the number of known’s which is 61. While it is true that additional data would have the increased reliability of the work it may be noted that collection of all these input parameters simultaneously in the monsoon environment in the sea is very difficult. Haykin’s reference is now added.

2. Second ANN: The purpose of using the second ANN is not at all clear. The authors are using the measured littoral drift as the target output of the first ANN model. The target output of the second ANN model is also the same. The logic behind this selection may please be elaborated. Why the second model would "fine tune" the prediction of the first ANN model? Any available literature on this aspect may also be referred. In the ANN literature sometimes the error of a model is used in another model to "fine tune" the result of the first model, however, the authors are not following the same principle.

In some way we are also using errors produced by the main network to train another network and in that sense this may be viewed as ‘fine tuning’.

3. Selection of inputs: The authors made an exhaustive search for the input variables by iterating selection of new set of input variables, training a model and comparing the

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model’s performance on the testing dataset containing 20 data points. Probably the authors also could have chosen the input variables based on the physics of the process and/or making a data analysis involving correlation analysis or average mutual information.

The physics of the underlying process dictated use of all the input variables (considered in the beginning, before the pruning was done). The correlation analysis was also made but the method selected yielded the best results. (In some way these methods are alternatives.) The longshore sediment transport in the study area is induced mainly by wave breaking, than due to tide or wind-driven currents, hence the input parameters arrived after pruning are related to wave breaking. Considering the physical process, the sediment size also needs to be an input parameter. But during the study period, the variations in the sediment size were relatively small with median grain size varying from 0.15 to 0.2. Hence including the sediment size did not yield good results. Also authors’ experience in this regard is that in neural networks many times the trials prove to be more useful than the statistical or similar scientific methods.

4. Data used: a) It will be useful to know whether the authors did any data analysis or not. The analysis of the data to detect any spurious data should also be reported. This is particularly important as the authors have also reported that collecting data "in fierce oceanic condition is a difficult task". b) More information on the data collection procedure may be useful. c) Due to the absence of any cross-validation dataset how did you prevent over-training? d) Statistics of the training and testing datasets will be useful. As the data is of limited size so data-plots could be provided. e) Results on the training dataset can additionally be presented.

a) Even though the data were collected for 115 days, after the quality checks, measurments of 81 days were used in the analysis. Similarly when all the parameters such as wave height, wave period, wave direction, longshore current speed and direction and sediment load at different trap locations along the surf zone, were not collected in a day due to malfunctioning of instruments or due to overtopping of traps, then the mea-

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surements of that day were not used in the analysis. b) Done. Please see response to comment 1 of referee #1. c) The training procedure had a built in cross validation. d) Given in the response to comment 1 of referee #1. Included in the revised text. Fig. 1 is now added to illustrate data scatter. Figures of repetitious nature in this regard are avoided. e) Fig 2 showing training error reduction is added.

5. Linear regression and non-linear regression models: These models do not have the same input variables as the ANN model. The reason may please be elaborated.

There was a printing error in equation (2). This is now corrected. The input in ANN and in all regression models is same.

6. The manuscript does not contain sufficient description of the physical process. Description of the existing formulae to compute littoral drift and their applicability elsewhere are not reported well.

A brief description is added in the first para of section 6. This is as follows: “The breaking waves mobilize the sediments that are subsequently moved by the wave induced longshore current. The parameters which influence the sediment transport rate at a location are breaking wave height, wave period, breaker angle, sediment size and the nearshore profile or the surf zone width. The longshore sediment transport in the study area is induced mainly by wave breaking, than due to tide or wind-driven currents, hence the input parameters arrived at after pruning are related to wave breaking. During the study period, the variations in sediment size were relatively small with median grain size varying from 0.15 to 0.2 mm Hence inclusion of the sediment size did not yield good results.”

Description of existing formulae is given under section 3.1.

Based on the comparison of the measured values with the three commonly used empirical equations, Kumar et al (2003), found that the CERC and the Walton and Bruno formula over predict the longshore sediment transport rate. The difference between the measured and calculated values is attributed to the use of empirical formulas developed for the high-energy coasts during relatively low wave conditions since the average wave height during the measurement period was only 0.8 m. Research is on to develop new empirical formulae based on different data sets collected at different parts of the world including the data used in the present study (Bayram et. al., 2007).

Following reference is added.

Bayram A, Larson, M and Hanson, H., 2007, A new formulae for the total longshore sediment transport rate, Coastal engineering, 54, 700-710.

7. Page 2501 line 21: if you know some variables are secondary why do you choose them particularly when the data is limited.

The above sentence is corrected as: ‘All of the causative variables listed above may not be equally influential in producing the drift at a given location.’

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 2497, 2007.