COMPARISON OF ARTIFCIAL NEURAL NETWORK APPROACH AND ANALYTICAL APPROACHES IN PREDICTING PERFORMANCE AND ENERGY REQUIRMENTS FOR SOME IRRIGATION SYSTEMS

BY

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Therefore, I dedicate this work to all of them.

ABSTRACT

Khaled Abdelwahed Mohamed Ahmed, Comparison of artificial neural network approach and analytical approaches in predicting performance and energy requirements for some irrigation systems, Unpublished Doctor of Philosophy Thesis, Ain Shams University, Faculty of Agriculture, Agricultural Engineering Department, 2006.

Evaluation of performance of irrigation systems is one from many solutions of water problems. This study compares the artificial neural network (ANN) approach with analytical solutions namely exact solution and dimensionless analysis, in order to predict of the performance and energy losses of irrigation systems.

Three irrigation systems were chosen for their widely used now days in EGYPT; those systems were gated (perforated) pipes system, solid set sprinkler system and surface trickle irrigation system. A computer friendly user interfaces were developed to help agricultural and extension engineers in decision making, planning and designing irrigation system.

To construct ANN models, the needed data were collected from Egyptian literatures, as well; experimental work had been conducted to test of those models.

The study use analytical solutions to analyze the performance of the three irrigation systems under study. The analytical solutions based on well known formulas used to predict head losses along gated pipes, sold set sprinkler laterals and surface trickle irrigation laterals. The performances of the three systems under study were calculated according to the standard indicators.

Finally, a comparison between the exists solution were made to investigate the differences.

For gated pipes system, the results from exact solution showed their were some differences between experimental works and references at the same discharge. In addition; a dimensionless analysis for gated pipes system results in the following formula:

$$H_f = 0.00211\, Q^{1.871} DP^{-4.804} GA^{0.036} SG^{0.185} LP^{1.017}$$

Where H_f is the friction loss along gated pipe (m), SG is the gate's spacing (m), DP is the pipe diameter (m), GA is the gate's area (m^2), LP is the pipe length (m) and Q is the pipe flow ($m^3.s^{-1}$).

Three ANN models were developed; all models were used three layers, one for inputs, one hidden and the third for output, the interconnection used sigmoid functions. The models were tested and verified with experimental works; the results of each model showed no significance difference in comparison of results obtained experimental work. The models were programmed with a friendly user interface to help the user with no or little knowledge in evaluating their system.

On other hand, for the solid set sprinkler system there were no significance differences between analytical solution and measurements for flow rates, as well as, head losses along the laterals. Furthermore, a dimensionless analysis for solid set sprinkler laterals results in the following formula:

$$H_f = 0.001203\, Q^{1.917} DL^{-4..892} LL^{1.05} SS^{0.0775} RH^{0.089}$$

Where H_f is the friction loss along gated pipe (m), SS is the sprinkler spacing (m), DL is the pipe diameter (m), RH is the riser height (m), LL is the lateral length (m), and Q is the pipe flow ($m^3.s^{-1}$).

A comparison between the developed model with the well known Dracy-Weisback and Hazin-Williams formulas, as well as, experimental data.

Like gated pipes system, three ANN models were developed to predict the head losses along the lateral, head losses at any point on the lateral, and finally to predict the uniformity coefficient and distribution coefficient for the system. The results of each model showed no significance difference in comparison of results obtained experimental work. The models were programmed with a friendly user interface to help the user with no or little knowledge in evaluating their system.

Finally; for the surface trickle irrigation system, the flow rates had no significance differences between analytical solution and measurements.

In addition; a dimensionless analysis surface trickle irrigation laterals results in the following formula:

$$H_f = 0.00154\, Q^{1.876} DP^{-4.612} DE^{0.021} ES^{0.084} LL^{1.015}$$

Where : H_f is the friction loss along gated pipe (m), LL is the pipe length (m), ES is emitter spacing (m), DE is the emitter diameter (m), DL is the lateral diameter (m), and Q is the lateral flow ($m^3.s^{-1}$).

Like previous systems, three ANN models were developed to predict the head losses along the lateral, head losses at any point on the lateral, and finally to predict the uniformity coefficient and distribution coefficient for the system. The results of each model showed no significance difference in comparison of results obtained experimental work. The models were programmed with a friendly user interface to help the user with no or little knowledge in evaluating their system.

The results of this study showed the higher accuracy of using ANN models than analytical models in respect of field data. In addition, this study showed usefulness of using ANN technique as extension tool.

Finally, this study recommended more studies well be helpful in improving ANN models and using them for agricultural and extension engineering

Key-words: Artificial neural network, Analytical solution, Irrigation systems, System performance, Energy requirements, Dimensional analysis.

9. APPENDIXES

Matlab script (moddy.m)

```
% The following MATLAB script plots the Moody Chart
% using the iterative Colebrool-White friction factor.
% The Colebrook-White correlation can be used for
% transitional and turbulent Reynolds numbers above 4000.
% The plot is generated between 4000 and 100.000.000.
% Called function: ffcw(RE, DH, ERH)
clear
% Set the Reynolds numbers
rn1=50;
rn2=50;
rn3=300;
rn=rn1+rn2+rn3;
Re1=linspace(400,2300,rn1);
Re2=linspace(2300,4000,rn2);
Re3=linspace(4000,100000000,rn3);
Re=[Re1 Re2 Re3];
%Re=linspace(400,100000000,300);
% Set the hydraulic diameter in meters.
Dh=0.01;
% The relative roughness is calculated as the ratio between the equivalent roughness
% and the hydraulic diameter
rr=[0.05 0.04 0.03 0.02 0.015 0.01 0.008 0.006 0.004 0.002 0.001 ...
    0.0008 0.0006 0.0004 0.0002 0.0001 0.00005 0.00001 0.000005 0.000001];
% Set the equivalent roughness height in m.
eqrough=rr.*Dh;
% Calculate the friction factors
for j=1:20    % set the outer loop size to the number of rel.roughness values
  for i=1:rn  %set the inner loop size to the number of Reynolds numbers
```

```
  fcw(i,j)=ffrough(Re(i), Dh, eqrough(j));
 end
end
% Draw the Moody Chart
Fig.(1);
h=get(0,'CurrentFig.');
set(h,'Name','MOODY CHART','NumberTitle','off');
orient landscape;
loglog(Re,fcw(:,1),Re,fcw(:,2),Re,fcw(:,3),Re,fcw(:,4),Re,fcw(:,5),Re,fcw(:,6),...
  Re,fcw(:,7),Re,fcw(:,8),Re,fcw(:,9),Re,fcw(:,10),Re,fcw(:,11),Re,fcw(:,12),...
  Re,fcw(:,13),Re,fcw(:,14),Re,fcw(:,15),Re,fcw(:,16),Re,fcw(:,17),Re,fcw(:,18),...
  Re,fcw(:,19),Re,fcw(:,20));
set(findobj('Type','line'),'Color','k','LineWidth',1.2);  %set all the lines black, and
the line width to 1.2 from 0.5 (default)
grid on;
axis ([400 10^8 0.008 0.1]);
set(gca,'ytick',[0.008 0.009 0.01 0.015 0.02 0.025 0.03 0.04 0.05 0.06 0.07 0.08
0.09 0.1]);
xlabel('{\bf Reynolds number} {\it ( Re={UD_h}/\nu )}');
ylabel('{\bf Friction factor} {\it ( f_{cw} )}');
title ('{\bf MOODY CHART}','FontSize',13);
text(2.5*10^8,0.018,'{\bf Relative roughness} {\it ( \epsilon / D_h
)}','FontSize',8,'Rotation',90);
text(1.05*10^8,0.072,'\it0.05','FontSize',7);
text(1.05*10^8,0.065,'\it0.04','FontSize',7);
text(1.05*10^8,0.056,'\it0.03','FontSize',7);
text(1.05*10^8,0.048,'\it0.02','FontSize',7);
text(1.05*10^8,0.044,'\it0.015','FontSize',7);
text(1.05*10^8,0.038,'\it0.01','FontSize',7);
text(1.05*10^8,0.035,'\it0.008','FontSize',7);
text(1.05*10^8,0.032,'\it0.006','FontSize',7);
text(1.05*10^8,0.028,'\it0.004','FontSize',7);
```

```
text(1.05*10^8,0.0232,'\it0.002','FontSize',7);
text(1.05*10^8,0.0196,'\it0.001','FontSize',7);
text(1.05*10^8,0.0186,'\it0.0008','FontSize',7);
text(1.05*10^8,0.0174,'\it0.0006','FontSize',7);
text(1.05*10^8,0.016,'\it0.0004','FontSize',7);
text(1.05*10^8,0.0138,'\it0.0002','FontSize',7);
text(1.05*10^8,0.012,'\it0.0001','FontSize',7);
text(1.05*10^8,0.0106,'\it0.00005','FontSize',7);
text(1.05*10^8,0.0083,'\it0.00001','FontSize',7);
text(1.5*10^7,0.0083,'\it0.000005','FontSize',7);
text(5*10^6,0.0083,'\it0.000001','FontSize',7);
text(500,0.0115,'{\it To be used for laminar, transitional and}','FontSize',8);
text(500,0.0105,'{\it turbulent flows, for the full range of Reynolds numbers}','FontSize',8);
text(1.1*10^5,0.0175,'{\Smooth pipes}','FontSize',7,'Rotation',-36);
text(10^7,0.006,'MATLAB script by Kamahmed 2005','FontSize',6);
% ----------------- end of the script -----------------------------------
```

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