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Estimate of Crank Length for Best Performance of a Quick Return Motion Mechanism.

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ABSTRACT
The study, estimate of crank length for best performance of a quick return motion mechanism, was successfully carried out. The researchers considered variable crank length and the corresponding return angles of the crank at each length were recorded. MATLAB was used to analyze the tabular data. Training of crank length and return angle data using levenberg marquardt algorithm at 70% training data, 15% test data and 15% validation data respectively revealed that the best performance level was 0 at epoch 0 and this revealed lowest value of crank length less than 10 mm. The regression coefficient of 1 and correlation coefficient of 1.0000 from data analysis and graph indicated that there is a close and positive relationship between crank length and return angle of mechanism. However, MATLAB hypothesis result indicated otherwise. MATLAB analysis also computed the linear regression model between crank length and return angle.
The standard error was observed to be 0 when root mean square error was 0. The P-value and degrees of freedom (5) of the Regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model.
The researchers made the following recommendations: The crank length should not exceed 10mm to improve performance of quick return motion mechanism, revolute joint of the crank levers must be adequately lubricated to encourage smooth return motion, this study can also be done in future using other training algorithms, etc.
Keywords ---- MATLAB, algorithm, training data, crank length, return angle regression model.

I. INTRODUCTION

Background of the Study

According to (Shahba, Sheikh, Khartade & Dahake, 2017), the performance of a quick return motion mechanism is dependent on the time ratio of the mechanism. Time ratio here, implies ratio of time take during cutting stroke to the time taken during return stroke. The lesser the time of return stroke greater will be the time ratio and better will be the mechanism performance. This mechanism basically consists of four links as crank, frame, connecting rod and slider. The ram and lever connecting the ram is not the part of basic.

Quick return motion mechanism converts rotary motion of prime movers, such as electric motor into reciprocating motion.

There are varieties of quick return motion mechanism such as the offset crank slider mechanism, the crank-shaper mechanisms, the double crank mechanisms, crank rocker mechanism and Whitworth mechanism. The advantage of this quick return mechanism over other quick return mechanism is that, this is the simplest among all the mechanisms.

The crank length of a quick return motion mechanism to a greater extend affects the performance of the mechanism. Since the time taken for return stroke is less than its working stroke, it is called as quick return mechanism. He further added that increasing crank length will increase stroke length but may not necessarily assure best performance (Arup, 2016).

Khurmi and Gupter (2013) suggested that the uniform angular velocity of a quick return motion mechanism can be accelerated by increasing the mechanism crank length.

There are no doubts that increasing or decreasing the crank length of a quick return motion mechanism may not necessarily assure best operational performance of the mechanism. Hence, this research aimed at studying the estimate of crank length for best performance of a quick return motion mechanism.

Statement of Problem

Undoubtedly, since increase or decrease in crank length will either increase or decrease the mechanism stroke length, there is a need to determine an estimated value of crank length that would guarantee best operational performance and subsequently accelerate mechanism productivity.

.McCarthy and Soh (2010) opined that the operational performance of a quick return motion mechanism centers on joints (revolute joints) that form a closed chain and crank length. Each link has two joints, and the joints have various degrees of freedom to facilitate relative motion. It is on this note that the researchers aimed at determining the estimate of crank length for best performance of a quick return motion mechanism.

Purpose of the study

The general purpose of this study is to determine the crank length for best performance of the mechanism.

Significance of the Study

The result of this study will be beneficial to machine tool engineers and robotics industry, in the following ways:

1) The best crank length will increase machine productivity.

2) It can improve the design of pick and place robots.

Research Question

Is there any relationship between crank length and performance (return angle) in a quick return motion mechanism?

Hypothesis

Null hypothesis, H_0 = there is a significant relationship between crank length and performance (return angle) versus **Alternative hypothesis,** H_i = there is no significant relationship between crank length and performance (return angle) of a quick return motion mechanism.

Scope of the Study

This research will focus on studying the estimated crank length for best performance of the mechanism. So, all efforts will be directed towards the general objective. The data used for the analysis were gotten from a fabricated product in Federal Polytechnic Nekede, within South East of Nigeria. Results may be subject to variations within other parts of the World.

II. REVIEW OF RELATED LITERATURE

Shelare et al (2012) modeled crank and slotted quick return motion mechanism with crank length of 100mm and they discovered that the stroke length, crank and time ratio have relationships.

Arup (2016) studied adaptive design on crank and slotted lever mechanism. He concluded that multiple reciprocating motion can be obtained from the same mechanism at the same time frame.

Shahbaz et al (2017) evaluated computer aided modeling and analysis of slotted lever quick return mechanism using PTC Creo 3.0. They discovered that for a crank length of 100mm and time ratio of 4.3446 were possible.

Gupta(2012) studied theory of machines and simple mechanisms and he concluded that linkages are the foundation of machine design and creation and capable of producing rotational, translational and oscillation motions through the movement of crank. A linkage is called a mechanism if two or more links are movable with respect to a fixed link.

McCarthy and Soh (2010) examined geometric design of linkages and discovered that four-bar-linkage is a series of four rigid links connected with joints (revolt joints) to form a closed chain. Each link has two joints, and the joints have various degrees of freedom to allow relative motion. They also added that Four-bar-linkage play a key role in industrial machines, robotics, conveyors, diesel engines, and therefore, demands accurate configuration angles if the machines must perform satisfactorily. Plecnik and McCarthy(2014) studied numerical synthesis of six bar linkage for mechanical computation and they opined that, four-bar-linkage synthesis is to determine link dimensions of the linkage that achieves prescribed task positions. Traditionally, linkage synthesis is divided into three types, motion generation, function generation, and path generation. Jain and Gupta (2011) experimented four bar linkage and they concluded that it is made up of four links, three movable links, four joints, one fixed link and one constraint.

III. METHODS AND DATA PRESENTATION

The study considered variable crank lengths and corresponding return angles of the crank at each length was recorded. The data was analyzed using MATLAB, to determine the best

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(crank length) for best performance of the mechanism. See table 3.0

Table 1.0; crank length with observed return angles.

S/N	Crank length in (mm)	Observed return angle in degrees
1	10	80.5
2	20	161
3	40	322
4	50	402.5
5	65	523.25
6	70	563.5
7	80	644

MATLAB Scrips/Codes for the training Graphs below.

```
% Solve an Input-Output Fitting problem with a Neural Network
% Script generated by Neural Fitting app
% Created 02-May-2022 12:32:06
%
% This script assumes these variables are defined:
%
%   data - input data.
%   data - target data.

x = data;
t = data;

% Choose a Training Function
% For a list of all training functions type: help nntrain
% 'trainlm' is usually fastest.
% 'trainbr' takes longer but may be better for challenging problems.
% 'trainscg' uses less memory. Suitable in low memory situations.
trainFcn = 'trainlm';  % Levenberg-Marquardt backpropagation.

% Create a Fitting Network
hiddenLayerSize = 10;
net = fitnet(hiddenLayerSize,trainFcn);

% Setup Division of Data for Training, Validation, Testing
net.divideParam.trainRatio = 70/100;
net.divideParam.valRatio = 15/100;
net.divideParam.testRatio = 15/100;

% Train the Network
[net,tr] = train(net,x,t);

% Test the Network
```

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```
y = net(x);
e = gsubtract(t,y);
performance = perform(net,t,y)

% View the Network
view(net)

% Plots
% Uncomment these lines to enable various
plots.
%figure, plotperform(tr)
%figure, plottrainstate(tr)
%figure, ploterrhist(e)
%figure, plotregression(t,y)
%figure, plotfit(net,x,t)
```

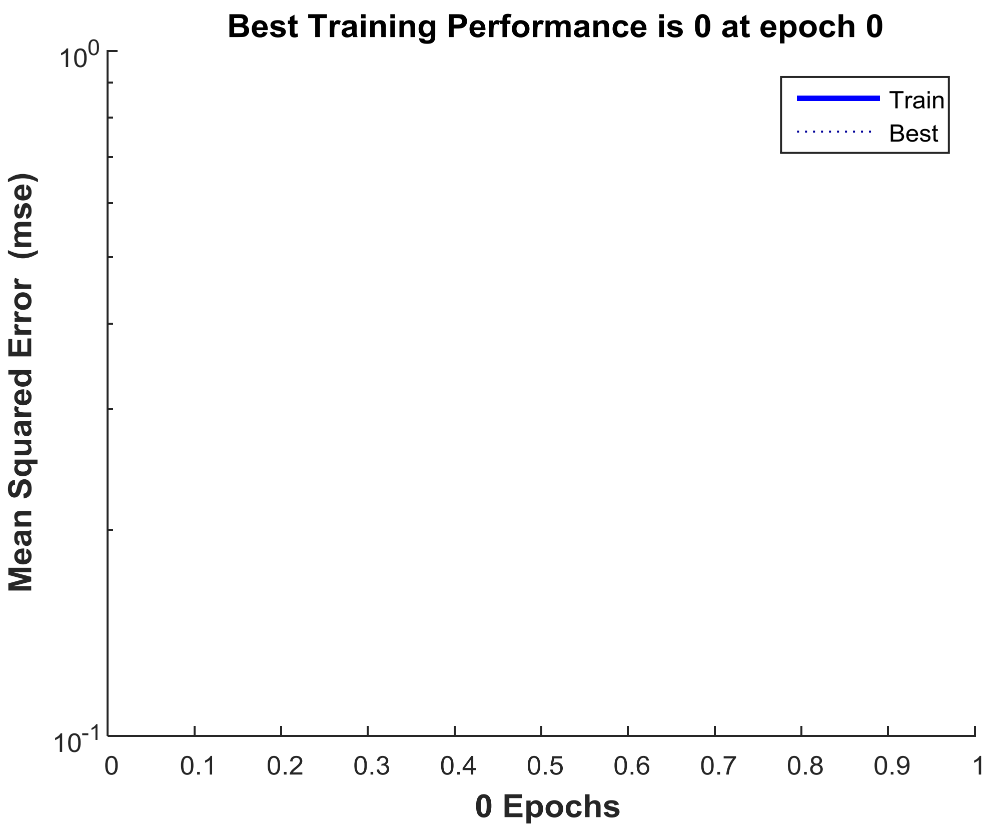

Fig 1.0; Training Performance Graph

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Fig 1.1; Regression Graph

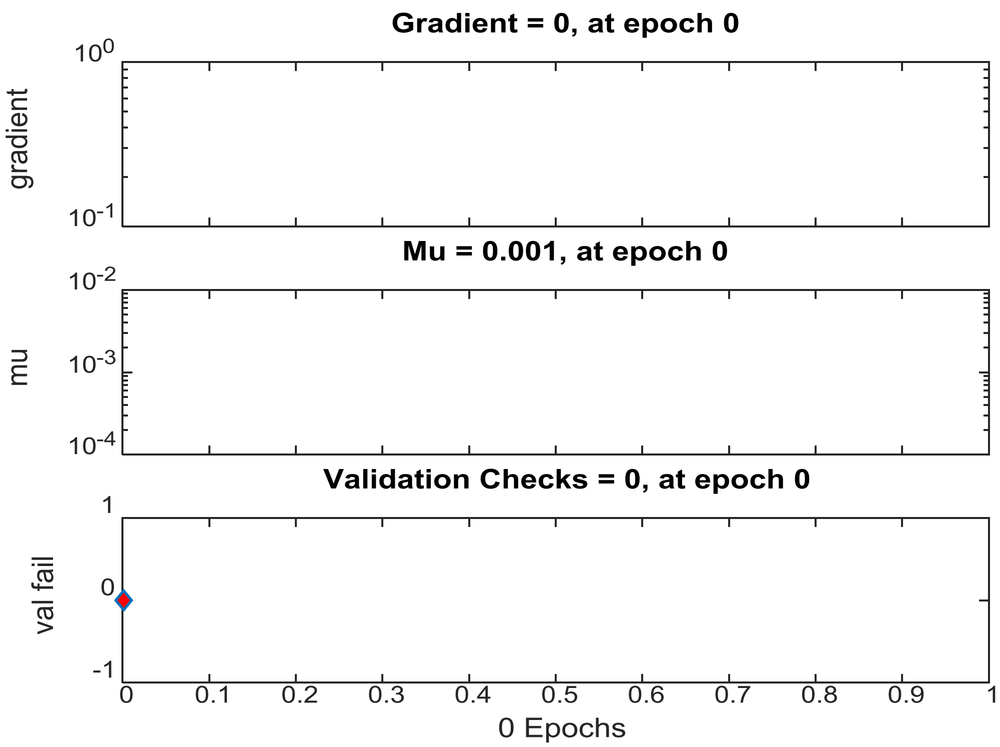

Fig 1.2; State training Graphs

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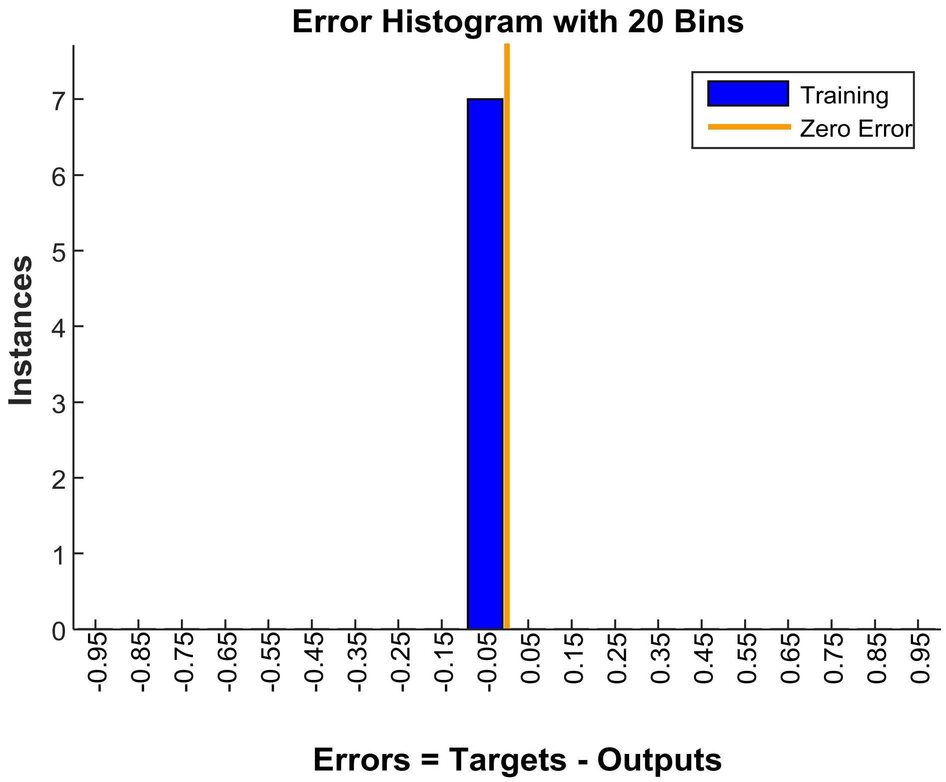

Fig 1.3;Error Training Graph

MATLAB Function for the training Graphs above.

```
function [Y,Xf,Af] = myNeuralNetworkFunction(X,~,~)
%MYNEURALNETWORKFUNCTION neural network simulation function.
%
% Generated by Neural Network Toolbox function genFunction, 02-May-2022 12:27:57.
%
% [Y] = myNeuralNetworkFunction(X,~,~) takes these arguments:
%
%   X = 0xTS cell, 0 inputs over TS timsteps
%
% and returns:
%   Y = 0xTS cell of 0 outputs over TS timesteps.
%
% where Q is number of samples (or series) and TS is the number of timesteps.

%#ok<*RPMT0>

% ===== NEURAL NETWORK CONSTANTS =====


% ===== SIMULATION ========

% Format Input Arguments
isCellX = iscell(X);
if ~isCellX, X = {X}; end;

% Dimensions
TS = size(X,2); % timesteps

% Allocate Outputs
Y = cell(0,TS);

% Time loop
for ts=1:TS

end

% Final Delay States
Xf = cell(0,0);
Af = cell(0,0);

% Format Output Arguments
if ~isCellX, Y = cell2mat(Y); end
end

% ===== MODULE FUNCTIONS ========
```

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```
%MATLAB REGRESSION AND ANOVA ANALYSIS OF CRANK LENGTH AND RETURN ANGLE(PERFORMANCE)

>> CRAN =[10 20 40 50 65 70 80];
>> RETURN = [80.5 161 322 402.5 523.25 563.5 644];
>> mdl = fitlm(CRAN,RETURN)

mdl =


Linear regression model:
   y ~ 1 + x1

Estimated Coefficients:
                   Estimate    SE   tStat   pValue
                 __________    __   _____   ______


   (Intercept)   4.7642e-14    0    Inf     0
   x1                 8.05     0    Inf     0


Number of observations: 7, Error degrees of freedom: 5
Root Mean Squared Error: 0
R-squared: 1,  Adjusted R-Squared 1
F-statistic vs. constant model: Inf, p-value = 0
>> tbl = anova(mdl)

tbl =

           SumSq         DF       MeanSq         F       pValue
         __________      __     __________      ___      ______


   x1    2.6523e+05      1     2.6523e+05    Inf      0
   Error          0      5              0

>> [h,sig,ci] = ttest(CRAN,RETURN)

h =

   1


sig =

   0.0029


ci =

 -507.6856 -167.1001

>> [r,p] = corrcoef(CRAN,RETURN)

r =

    1.0000    1.0000
    1.0000    1.0000


p =

    1.0000    0.0000
    0.0000    1.0000

>> end
```

IV. DISCUSSION OF FINDINGS

The outcome of the study of estimate of crank length for best performance of a quick return motion mechanism was discussed here. The data was analyzed using MATLAB. According to table 1.0, the original data was trained to achieve a network best performance test level. Training of crank length and return angle data using levenberg marquardt algorithm at 70% training data, 15% test data and 15% validation data respectively revealed that the best performance level was at 0 and at epoch 0 and this indicated lowest value of crank length less than 10 mm. The regression coefficient of 1 and correlation coefficient of 1.0000 from data analysis and graph indicated that there is a close and positive relationship between crank length and return angle of mechanism.

The MATLAB analysis also computed the linear regression model between crank length and return angle;

$$\textbf{Return Angle} = 8.05 \times \textbf{crank length} + 4.7642\text{e} - 14$$

The standard error was observed to be 0 when root mean square error was 0. The P-value and degrees of freedom (5) of the regression model are consistent with the P-value and degrees of freedom of ANOVA model, that proves correctness of the model.

V. CONCLUSION

Obviously, results from the study revealed that the best estimated value of crank length for best performance a quick return motion mechanism is less than 10mm which will give the shortest return angle. This is also in line with Shahbaz et al (2017) who claimed maximum crank length of 100mm.

Recommendations

The following recommendations are suggested based on the study:

1) The crank length should not exceed 10mm to improve performance mechanism.
2) Revolute joint of the crank levers must be adequately lubricated to encourage return motion.
3) This study can also be done in future using other training algorithms.
4) This research can also be done using multiple crank lengths and other advanced program for generalization.

Research Question

Is there any relationship between crank length and performance (return angle) in a quick return motion mechanism?

Hypothesis

Null hypothesis, H_0 = there is a significant relationship between crank length and performance (return angle) versus **Alternative hypothesis,** H_i = there is no significant relationship between crank length and performance (return angle) of a quick return motion mechanism.

```
>> [h,sig,ci] = ttest(CRAN,RETURN)

h =

    1


sig =

   0.0029


ci =

 -507.6856 -167.1001
```

At hypothesis of **1**, we accept **alternative hypothesis** H_i = there is no significant relationship between crank length and performance (return angle) of a quick return motion mechanism.

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