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Nomoto Model Evaluation

Objective:

To evaluate the performance of first order nomoto model which will be used as an agent in reinforcement learning system for ship's navigation.

Work done :
Model has been encoded in python

First Order Nomoto Model:

$$\boxed{T\dot{r} + r = K\delta}$$

—-(1)

by soling this first order linear equation, we can get the relation between yaw rate and given rudder angle,

$$r = K\delta_0 \left(1 - e^{-t/T}\right)$$

—-(2)

As we know that, from governing equation k and T are nomoto model parameters. in order to calculate these values,

$$\begin{aligned} I_z\dot{r} + mx_G(\dot{u} + u_0 r) &= N \\ &= N_r.r + N_{\dot{r}}.\dot{r} + N_\delta.\delta \end{aligned}$$

rearranging this equation,

$$[I_z - N_{\dot{r}}]\dot{r} + [mx_G u_0 - N_r]r = N_\delta.\delta$$

when converting into the form of governing equation,

$$\underbrace{\frac{[I_z - N_{\dot{r}}]}{[mx_G u_0 - N_r]}}_{\text{T}}\dot{r} \quad + \quad r \quad = \quad \underbrace{\frac{N_\delta}{[mx_G u_0 - N_r]}}_{\text{K}} \quad \delta$$

—-(3)

with standard reference from **I.T.T.C**, T and K values should follow the following range,Accordingly, it is considered that K indicates the angular velocity eventually reached, and therefore turning ability, and T indicates the quickness from moving from one stationary state to another stationary state $i.e$ quick responsibility

$$\begin{aligned} T &\longrightarrow \text{ranging from 0.1 to 100} \\ K &\longrightarrow \text{ranging from 0 to 0.999} \end{aligned}$$

We can take this numerical values from MMG model, Yasukawa Paper which belongs to $KVLCC2$ tanker ship,

x_G = 11.2,
m = 3.126 $\times$ 10^8,
u_0 = 7.75,
I_z = 1.99 $\times$ 10^{12}
N_d = 5.8 $\times$ 10^11
N_r = -1.3309 $\times$ 10^11
$N_{\dot{r}}$ = 1.199 $\times$ 10^{12} ***(subjected to change)*** for this value $k = 0.49$ and $T = 3.619$

Here, Encoded Nomoto model is evaluated for constant $T = 15$ and different set of K values, **80 step units were taken** for $\delta = 35$ degree

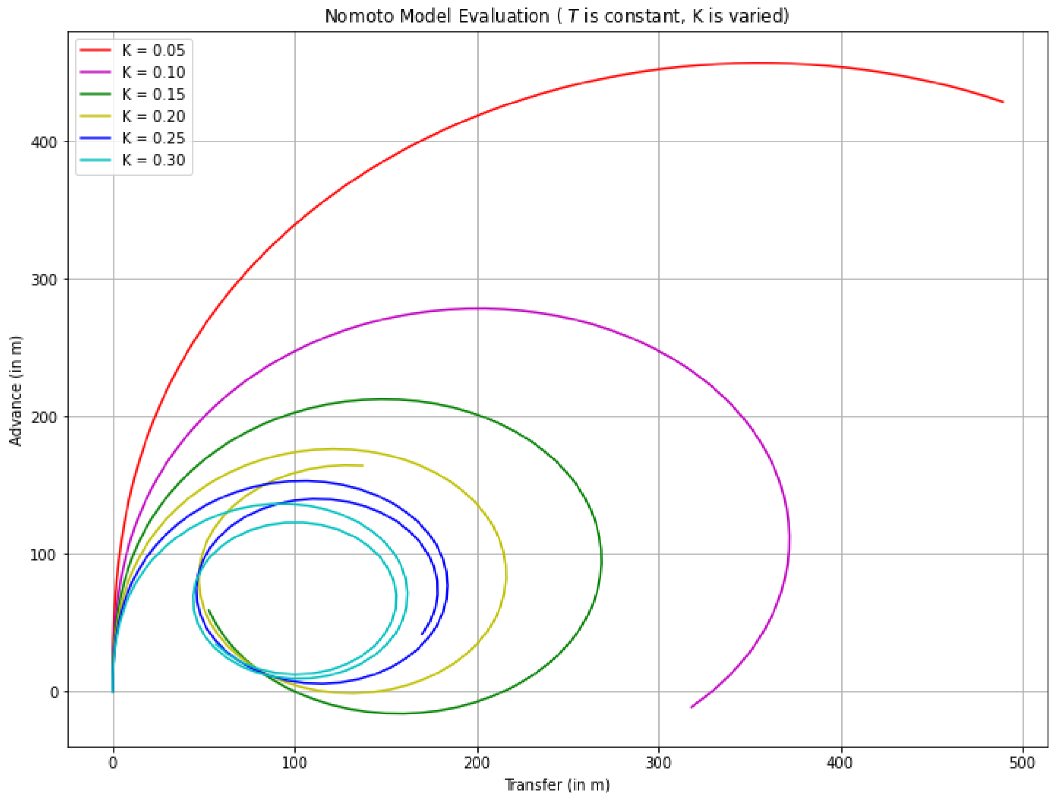

Figure 1 . Nomoto Model for $T = C$ and different K
Source : $Nomotodof1.py$

Similarly, for constant $K = 0.15$ and different T values, **80 step units were taken** for $\delta = 35$ degree.

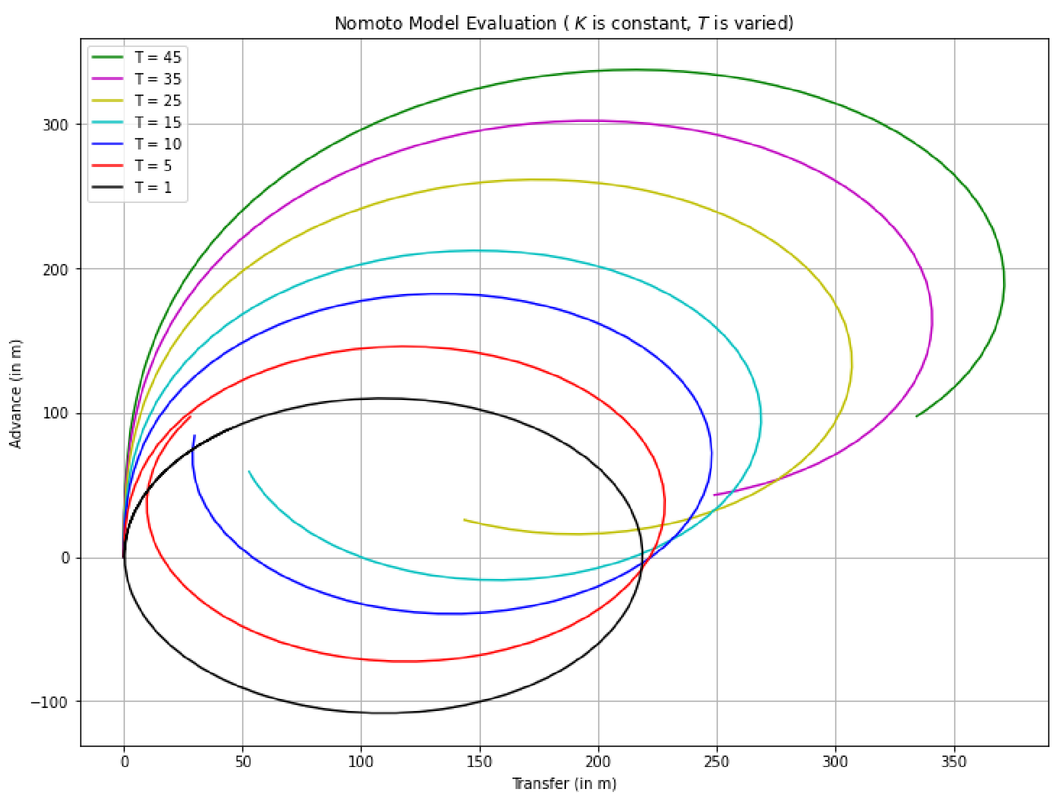

Figure 2 . Nomoto Model for $K = C$ and different T
Source : $Nomotodof1.py$

Here, different combination of T and K values have been taken, **80 step units were taken** for $\delta = 35$ degree.

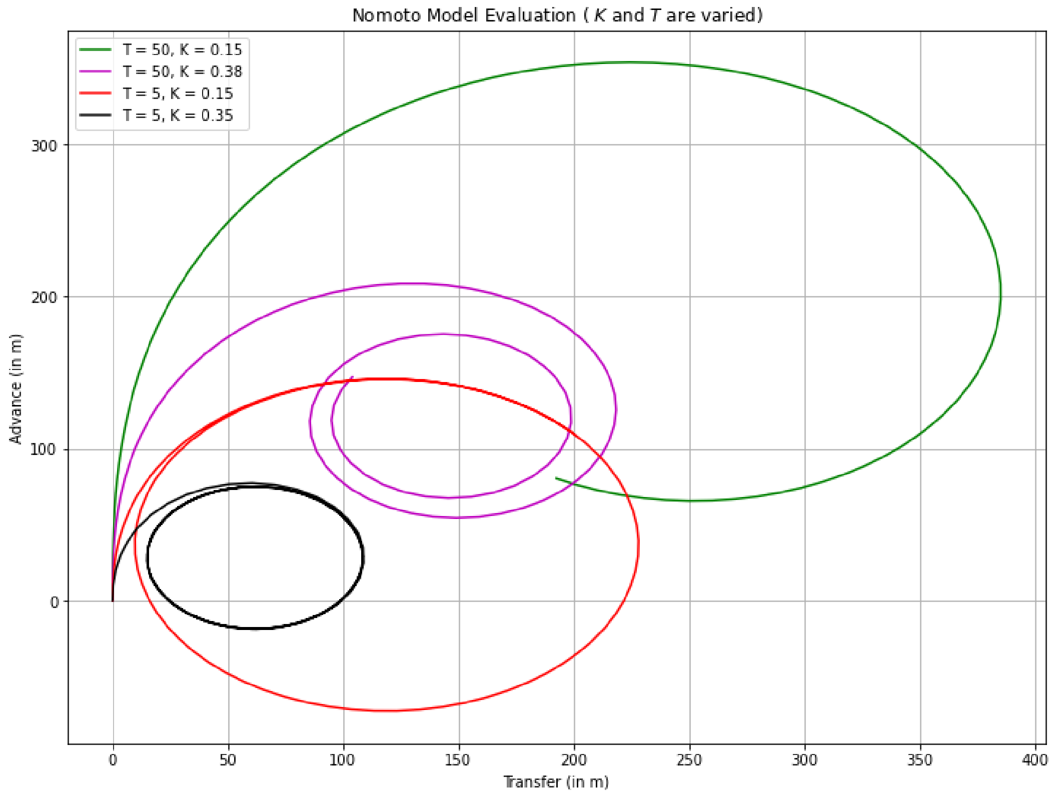

Figure 3 . Nomoto Model for different T and K
Source : $Nomotodof1.py$

At extend, Agent's action for straight line motion for any value of T and K, **100 step units were taken** for $\delta = 0$ degree.

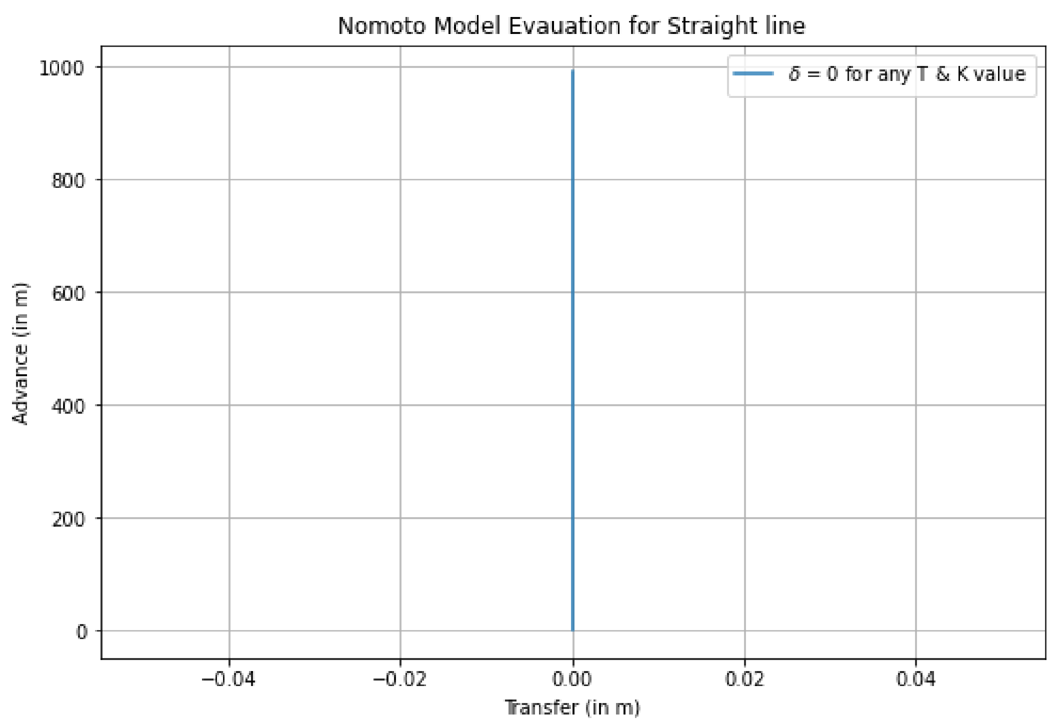

Figure 4 . Nomoto Model for straight line action
Source : $Nomotodof1.py$

Here, the evaluation of $KVLCC2$ ship model for aforementioned values **50 step units were taken** for $\delta = 35$ degree.

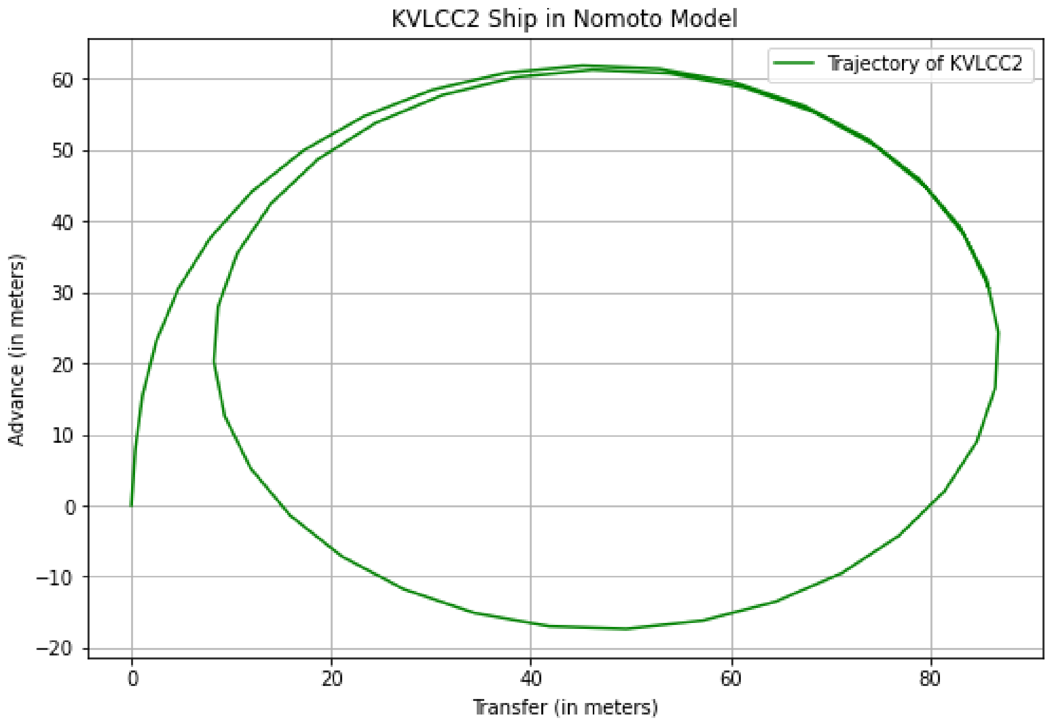

Figure 5 . $KVLCC2$ ship evaluation with nomoto model
Source : $Nomotodof1.py$