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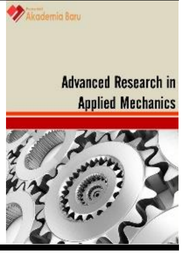

Computer Simulation and Modeling In Engineering for Open Learning Environment – A Case Study on Application of Rand Model Designer for Ship Manoeuvring Analysis

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ABSTRACT

Computer simulation and modeling pave an upcoming methodology of teaching and learning of engineering courses reachable by unlimited number of students in open learning environment. The delivery of engineering courses through open learning poses much bigger challenges as compared to non-engineering courses. Typical engineering problems are mathematically modelled, simulated and solved using computer software as engineering tools. The use of computer software engineering tools could be linked to open source licensed software from the open learning platform, such as Sakai. Sakai is an educational software platform designed to support teaching, research and collaboration distributed under the educational community license. Rand Model Designer (RMD) is high-performance software for modeling and simulation of multi-domain component models of complex dynamical systems. It employs a user-friendly, high-level, object-oriented modeling language for fast and efficient design of complex continuous, discrete and hybrid models. In the case study RMD has been used for ship maneuvering analysis. The results indicate that RMD is a compatible, viable, practical and competitive engineering tool for solving complicated computational experiments and simulations in open learning environments of engineering education.

Keywords:
Computer Simulation and Modelling; Open Learning Environment; Discreet and Hybrid Models; Rand Model Designer; Ship Maneuvering Analysis

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1. Introduction

The delivery of academic courses online popularly known as Massive Open Online Courses abbreviated as MOOCs is the current and future trend of course delivery to unlimited participants or students through internet or webs. This online method of delivery of courses is available conveniently with interactive modes which support forums of discussions, tutorials, examination, virtual laboratories and other teaching and learning activities which no longer limited between a student

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and a teacher or educator but in large groups of students and the teachers taking place in real times concurrently.

There are several open learning platforms available in use for MOOCs the most popular being the edX, moodle, COURSEsites, udemy, versal, sakai [1] and others. These platforms could handle a massive number of participants and some are unlimited. Some of the characteristics embedded in these platforms are their speed, robustness, ability to sign up large number of students, built in with course management systems and tools, user-friendly, software stability, functionality, versatility and ability of linking with external systems and teaching and learning tools and charges to users. The other important feature that is sought for the delivery of the course contents or syllabus for engineering courses is the ability to take or link with engineering software to solve and analyse efficiently complex engineering calculations and problems which are mathematically modeled or simulated. This requirement could pose challenges in engineering education. In order to facilitate in overcoming these challenges could be achieved by utilising web open source licensed computer software engineering tools which are necessary to be linked suitably through the open learning platforms.

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In this paper, computer software Random Model Designer (RMD) [2] is used in a case study to perform engineering analysis on ship maneuvering characteristics of a ship. As announced by the software developer of the software, RMD is a high-performance visual environment software for object-oriented modelling of multi-domain component models. RMD is a Russian software product developed by Distributed Computing and Networking Department of the Peter the Great Saint-Petersburg State Polytechnic University Technical Cybernetics School.

2. The Maneuvering Governing Equations

The ship maneuvering analysis makes use of the well-known equations [3] for linear equations of motion approximation in the forms of non-dimensional hydrodynamic derivatives given below.

$$m'\dot{u}' = X'_u u' + X'_v v' \tag{1}$$

$$m'\left[\dot{v}' + V' r' + x'_{cg}\dot{r}'\right] = Y'_v v' + Y'_{\dot{v}}\dot{v}' + Y'_r r' + Y'_{\dot{r}}\dot{r}' + Y'_\delta \delta_R \tag{2}$$

$$I'_z \dot{r}' + m' x'_{cg}(V' r' + \dot{v}') = N'_v v' + N'_{\dot{v}}\dot{v}' + N'_r r' + N'_{\dot{r}}\dot{r}' + N'_\delta \delta_R \tag{3}$$

The above equations could be solved separately however Eq. (2) for yaw and Eq. (3) for sway to be solved simultaneously and the results could be used to solve Eq. (1) for surge by substitution. The above equations for yaw and sway could be rewritten in matrix forms as follows:

$$\begin{pmatrix} (m'-Y'_{v}) & -(Y'_{r}-m'x'_{cg}) \\ -(N'_{\dot{v}}-m'x'_{cg}) & (I'_z-N'_{\dot{r}}) \end{pmatrix}\begin{pmatrix}\dot{v}' \\ \dot{r}'\end{pmatrix} + \begin{pmatrix} -Y'_v & -(Y'_r - m'V') \\ -N'_v & -(N'_r - V'm'x'_{cg})\end{pmatrix}\begin{pmatrix} v' \\ r'\end{pmatrix} = \begin{pmatrix} Y'_\delta \delta_R \\ N'_\delta \delta_R\end{pmatrix} \quad (4)$$

where,

X = sum of all forces acting on the hull in ship-fixed abscissa axis or surge or axial forces
Y = sum of all forces acting on the hull in ship-fixed ordinate axis or sway forces
N = sum all moments acting on the hull in horizontal plane or yaw moments
X_{Rd}, Y_{Rd}, and N_{Rd} are corresponding rudder forces and moment
u = surge or axial component of instantaneous speed
$\dot{u}$ = surge or axial acceleration
v = sway velocity
$\dot{v}$ = sway acceleration
r = yaw rate or yaw angular velocity
$\dot{r}$ = yaw acceleration
m = vessel mass
I_z = mass moment of inertia of a vessel relative to vertical axis
X_{cg} = abscissa of the center of gravity

The trajectory of the turning circle motion could be determined and drawn by evaluating the surge and sway velocities with reference to appropriate global coordinate systems as follows:

$$\dot{x}(t) = u(t)\cos(\Psi(t)) - v(t)\sin(\Psi(t)) \quad (5)$$

$$\dot{y}(t) = u(t)\sin(\Psi(t)) - v(t)\cos(\Psi(t)) \quad (6)$$

The x and y coordinates as a function of time are therefore given below:

$$x(t) = \int_0^t \dot{x}(t)\,dt \quad (7)$$

$$y(t) = \int_0^t \dot{y}(t)\,dt \quad (8)$$

3. Solution of the Equations of Motion

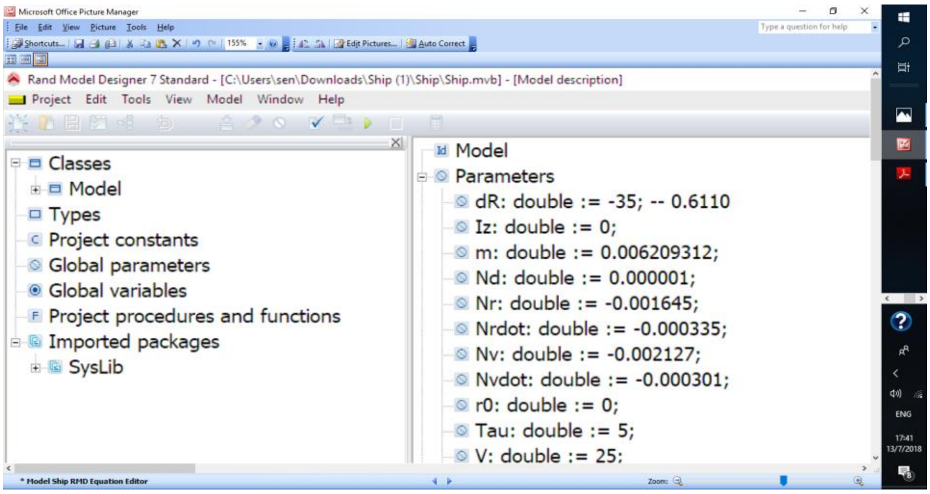
The above equations of motion were simulated for a linear motion case using the ship's data given in Table 1.

Table 1
Ship Data

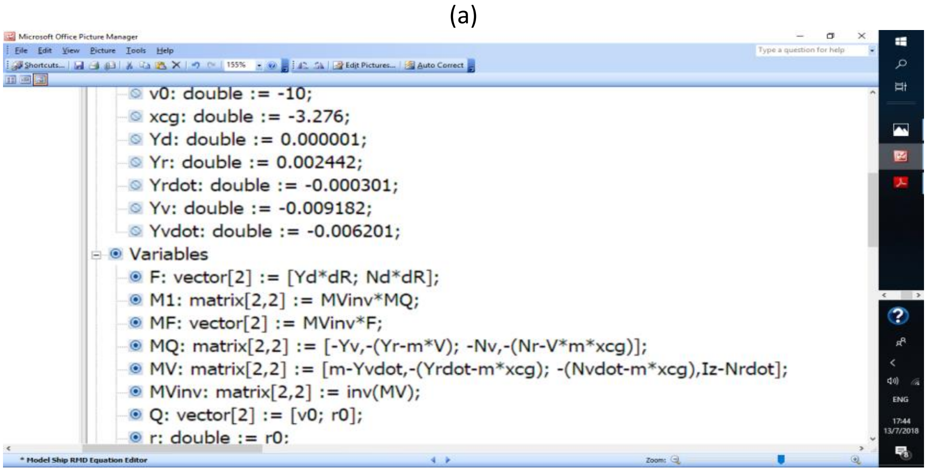
L_{WL} (m):	82.800	c (fluid):	6.000
B(m):	12.850	m' = m/0.5L$^{3:}$	0.006209312
T (m):	3.400	ρ (kg/m^3):	1025.000
C_B:	0.485	π(T/L)$^{2:}$	-0.005
A_R (m^2) DNV:	3.613	x_{cg} (m):	-3.276
A_R (m^2) Actual:	5.830	m (10^{-3} x kg):	1762.400
C_L:	0.950	δ_R(Radians):	-0.611
$\delta C_L/d\delta$:	0.024	V_s (m/s):	12.861
Ω:	10.000	V_s (knot):	25.000
Mean Span (m):	2.300	Rudder Angle δ_R:	-35.000
Mean Chord (m):	2.407	Interval dt (s):	5

4. RMD Model Equations Editor

Screen shots of the RMD model equations editor are given below:



(a)



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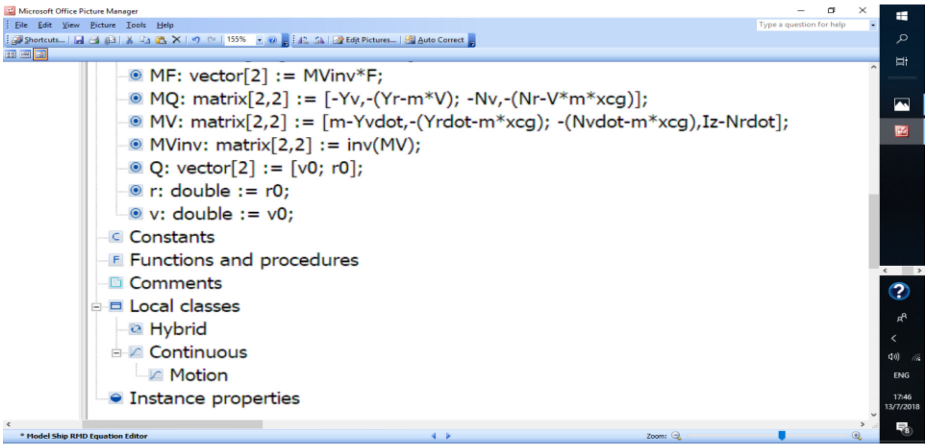
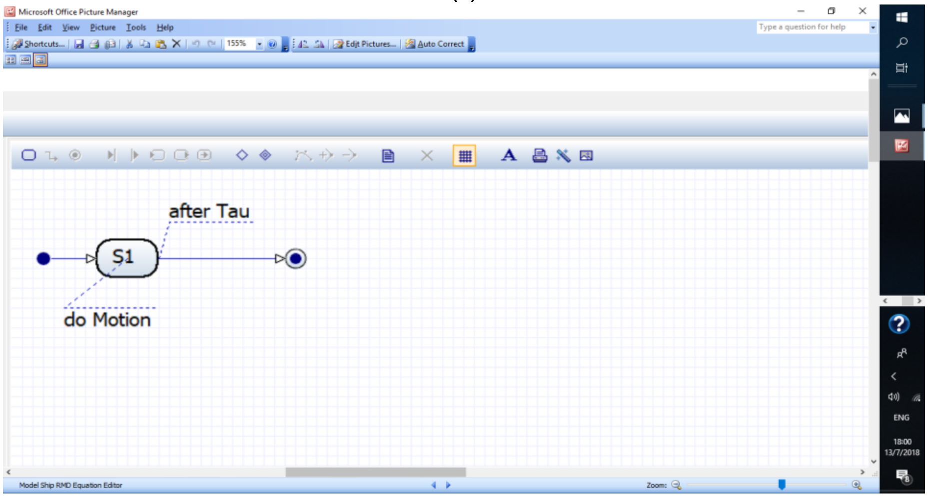


(c)



(d)

Fig. 1. Model equations editor (a) – (d)

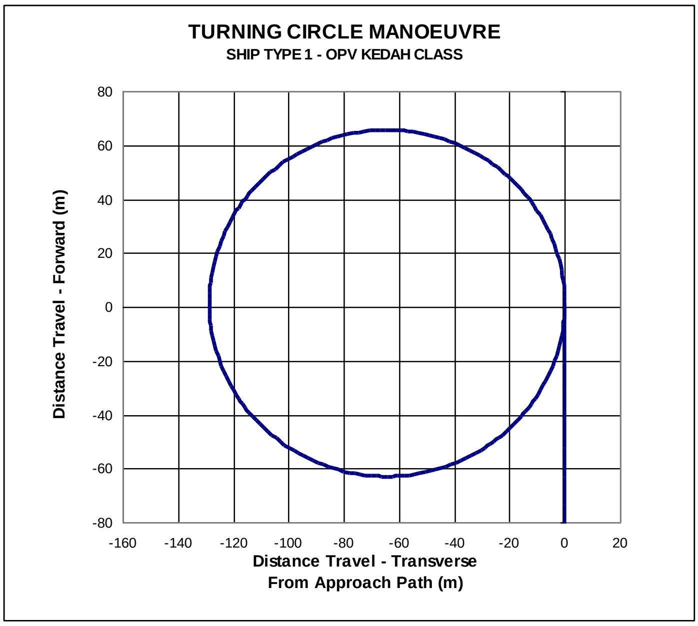


Fig. 2. Model equations editor (a) – (d)

Table 2
Results for turning circle maneuver

Ship Speed, V_s (kn)	25
Rudder Angle, δ_R	-35
Transfer (m)	64.305
Maximum Transverse (m)	0.013
Minimum Transverse (m)	128.596
Tactical Diameter (m)	128.609
Advance (m)	65.617
Tactical Diameter/L	1.553
Steady Turning Radius (m)	64.305
Time to attain 90° turn (min)	4.258
Time to attain 180° turn (min)	8.517
Time to attain 360° turn (min)	17.033

6. Conclusion

In the case study RMD has been used for a typical ship turning circle maneuvering analysis and the results indicate that Random Model Designer (RMD) software is a proven software for modeling and simulation of multi-domain component models of complex dynamical systems. It employs a user-friendly, high-level, object-oriented modeling language for fast and efficient design of complex models. It is a compatible, viable, practical and competitive engineering tool for solving complicated computational simulations and experiments**.** The software could be linked suitably through open learning platforms of web open source licensed software in the purchase agreement for online application by subscribers or users. The RMD software is being part and parcel of the InMotion Project and used by the participating universities.

Acknowledgement
We greatly acknowledged the consent from the Royal Malaysian Navy for the use of the ship data used in the simulation of the analysis. The application of the software Rand Model Designer v.7.1.6 from the Distributed Computing and Networking Department of the Peter the Great Saint Petersburg State Polytechnic University Technical Cybernetics School had been very useful for the case study.

References

[1] https://sakaiproject.org/ June 2018.
[2] MVSTUDIUM. "Rand Model Designer - high-performance visual environment for object-oriented modeling of multi-domain component models." http://www.mvstudium.com/eng/ June 2018.
[3] American Bureau of Shipping (ABS), Guide for Vessel Maneuverability, March 2008.
[4] http://inmotion-project.net/index.php/en/links June 2018.
[5] Zwolan, Piotr, and Krzysztof Czaplewski. "Analysis of a real vessel and its simulation model behavior." *Zeszyty Naukowe/Akademia Morska w Szczecinie* (2013).
[6] Mainal, Mohd Ramzan, and Mohd Salim Kamil. "Estimation of ship manoeuvring characteristics in the conceptual design stage." *Jurnal Mekanikal* 1, no. 1 (1996): 44-60.
[7] Tello Ruiz, M., M. Candries, M. Vantorre, G. Delefortrie, P. Peeters, and F. Mostaert. "Ship manoeuvring in waves: a literature review." *WL Rapporten* (2012).
[8] David Ckarke. "The Foundations of Steering and Manoeuvring." School of marine Science and Technology, MCMC Gerona, University of Newcastle Upon Tyne, 2003.
[9] M. Apri, N. Banagaay, J.B Van Den Berg, R. Brussee, D. Bourne, T. Fatima, F. Irzal, J. Rademacher, B. Rink, F. Veerman, and S. Verpoort. "Analysis of a Model for Ship Maneuvering." In *Proceeding of the 79th European Study Group Mathematics with Industry*, 83–116, 2011.
[10] Skejic, Renato. "Ships Maneuvering Simulations in a Seaway–How close are we to reality." In *Proceedings of the International Workshop on Next Generation Nautical Traffic Models*. 2013.