REVIEW

by Examination Board Member Prof. Konstantinos Spyrou
of dissertation submitted by Mr. Ivan Gennadevich Gankevich,
titled «Simulation modelling of irregular waves for marine object dynamics programmes»,
submitted for the science degree in speciality 05.13.18 «Mathematical modelling, numerical methods and programme complexes»

Before proceeding into the details of this review, I would recommend that the English title of the thesis is modified, possibly to the following or similar: "Novel modelling of irregular waves for simulating marine object dynamics".

The thesis represents a worthwhile effort for modelling ocean waves in a way overcoming the well-known shortcomings of the traditional linear superposition of regular waves commonly applied in the marine field. The thesis is quite well-written and original. Hence, I believe that the candidate is worthy the award of the Doctor's degree. Yet some improvements in the text would boost the readability of the thesis.

The author has selected to combine an "autoregressive model" (AR) and a "moving average" (MA) model, forming a so-called ARMA model in order to achieve the realistic reproduction of progressing waves. In general terms, the ARMA model is built in 3d version (x-y-t), so in principle short crested waves can be reproduced too. My understanding, although this is not completely clear from the text and I intend to have it clarified during the presentation, is that the AR model is basically a difference equation where a current property (e.g. wave elevation) at a given location is determined from information at a number of earlier time instants, with addition of a single stochastic impulse. In other words there is no space –related information involved in this scheme. On the other hand, the MA supplement of the ARMA model holds the spatial information (but not time) and for this reason it is vital for obtaining a progressing wave. If I understand correctly, the white noise of the MA model is handled through a convolution integral which the author suggests that it can be treated quite efficiently through distributed computing. The main input of the ARMA model is the autocovariance function which is easy to derive from spectral information or from raw data of wave elevation through analytical or empirical techniques.

Although the ARMA method does not account for the physics behind wave formation, it is indicated by the author to produce the correct values for sea wave parameters such as the dispersion relationship. Moreover, it treats equally well mild and steep waves (below the breaking limit). This provides a tremendous advantage over the conventional method which applies superposition of harmonics and is intrinsically limited to linear or mildly nonlinear waves.

I would like to know how one can optimally select the required number of earlier points in time and in space, respectively for the AR and MA processes. Is there any rule that the author would suggest?

The author has evaluated critically the literature on ocean applications of the ARMA model (final part of section 3.1) and although this part could have been more extensive it can be considered as adequate.

The 3d formulation of the governing equations of the ARMA model are given in section 3.2. However the author is advised to provide more explanations on how this model works computationally. For example, the impression is created that the AR model uses space-related information too. It is essential to explain what exactly has been implemented and verified. In general, I would have expected to see more graphs in section 3, supporting the workability of the method through illustrative examples.

The use of the non-linear intertialess tansform (NIT) is invoked in the paragraph with header "scientific novelty" (page 150) without any introduction justifying the use of this technique.

The calculation of the AR and MA processes coefficients (pages 157 to 162) is presented in an algorithmic manner, the reader cannot see the logic behind these computations. Some further explanations should be added, perhaps in an appendix.

An important novelty of the work lies in the formulation of a calculation method for deriving the pressure field under the wave profile (section 4). For engineering applications such knowledge of pressure and fluid velocity in the wave field is absolutely essential. I haven't come across other works on this problem and the author seems to be initiating this interesting topic. In the summary appearing at the end of this chapter the author should state clearly any simplifications that were needed for extracting the wave potential function, for large waves.

Due to the stochastic nature of the ARMA scheme, one-to-one comparison with a Longuet-Higgins deterministic wave realization, or indeed with a real wave produced in a tank, seems not possible. It will be good if the author could commend further on how his method could be validated in principle, beyond of course the level of producing waves that look realistic.

Other comments:

In cover page: Instead of "… programme complexes" write "…complex programming".

The term "realisation size" appearing in the Introduction (page 148) and elsewhere should better be replaced by "realization length".

Instead of "auto-covariate function" write "autocovariance function" (Introduction - page 149 and elsewhere).

In page 152: Instead of "Results verification and approbation" write "Results verification and validation".

In page 159, 1st line: Instead of "… compexifies the task,…" write "… makes the task more complex,…"

In page 162, give a reference for the condition of stationarity based on the roots of the characteristic equation.

Delete "Known" from the title of section 4.1 "Known pressure field determination formulae"

In the middle of page 181 change "arbitrary" to "realistic"

Middle of page 184: The function $f(x)$ could be easily confused with the function $f(x, y)$ appearing, for example, earlier on the same page.

End of page 185, beginning of page 186: the implication of imposing $\cosh(\ ) = \sinh(\ )$ should be evaluated for various distances from the free surface.

Page 186, beginning of last paragraph: the expression $\zeta(x,t) = A \cos(2\pi(kx-t))$ does not correspond to the expression of elevation that I know. Is it a typo?

Page 192, legend of figure 7: If I understand correctly, the selected wave does not satisfy the dispersion relation. Why choosing such a wave?

In section 5, page 196: I could not verify the dependencies explained in the text with what I see in figure 9.

Finally, some further English editing will be needed.

Dissertation board member, Konstantinos Spyrou
PhD, University of Strathclyde (UK)
Professor, School of Naval Architecture and Marine Engineering, National Technical University of Athens (Greece)

Signature _____ /Konstantinos Spyrou/

Date 11th of June 2018