HEAVE AWAY

Learning the language of algorithms

The digital transition will change our industry. To be prepared for this challenge, NHL Stenden University of Applied Sciences puts quite some effort in extending the relevant knowledge base, and in new types of digitally enabled education. An example is the TODDIS project. This four-year research project is aimed at collecting operational ship data and transforming these into tools and methods that can be utilised for ship design and operation. In addition, the school is also working on a game to educate an old trade: ship stability.

Big data, ubiquitous computing, neural networks, Internet of Things (IoT), sensors and sensor networks are the buzz words of this age. Popular media, business journals and scientific papers are cramped with reports on the phenomena and their expected future advancements. Yet, with an "Applied" in the name of our institute, philosophising or dreaming of a bright new world is not enough. In order to be able to support that other great transition of this day, the energy transition, these new tools need to be ruggedised and made fit for practical application in the maritime industry. With this aim, the project TODDIS was conceived at the Maritime Institute Willem Barentsz (MIWB) of NHL Stenden. TODDIS is an acronym for Transferring Operation Data into Design Information for Ships. In a nutshell, the governing idea behind TODDIS is to convert sensor information from and around ships into tools and methods, which support the design of new ships and operation of new and existing ships. TODDIS is conceived and managed by the MIWB, with as partners Amsterdam University of Applied Sciences, C-Job, Conoship International, Damen Shipyards, DEKC Maritime, Delft University of Technology, Goeree Lighthouse, Hydrographic and Marine Consultants, MARIN, NHL Stenden University of Applied Sciences, Rotterdam Mainport Institute, the Royal Netherlands Navy, Royal Wagenborg, Van Oord Dredging and Marine Contractors and We4Sea.

This large and diverse group of participants illustrates the broad support for the TODDIS goal and is a good mix between industry and multidisciplinary academia. The main goal, as explained above, is divided into six work packages:

1. Sensors: collecting, transferring and integrity of operational data.
2. State of the art: map and investigate current data collection and processing tools, with emphasis on their potential application in the maritime industry.
3. Develop tool(s) to support ship operation.
4. Develop tool(s) to support ship design.
5. Knowledge development for the minor Advanced Numerical methods for Shipping and Ship Design.
6. Normative aspects, and legal conditions and constraints.

These work packages do not have to be executed in this strict order. The TODDIS project started in January 2020 and currently progress is being made in work packages one, two and five, which will be elaborated on below.

First endeavours in TODDIS

TODDIS kicked off a little over six months ago and despite the hurdle of Covid-19 during the start of the project, in several work packages progress is made. Currently in the first work package, it has been concluded that conventional ship sensor networks are hardwired, which is accompanied by somewhat cumbersome installation and management procedures. Adding additional sensors is often a matter of visiting the ship; time consuming anyhow, while in Covid times also undesired. As an alternative, a pilot of an IoT net-

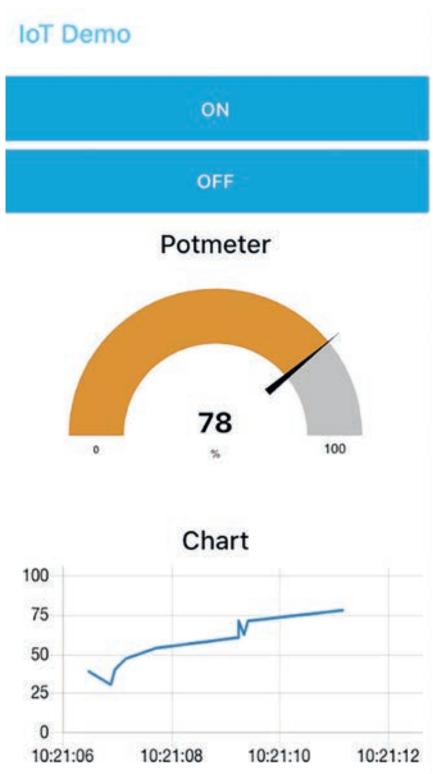

Figure 1. Remote presentation of sensor measurement.

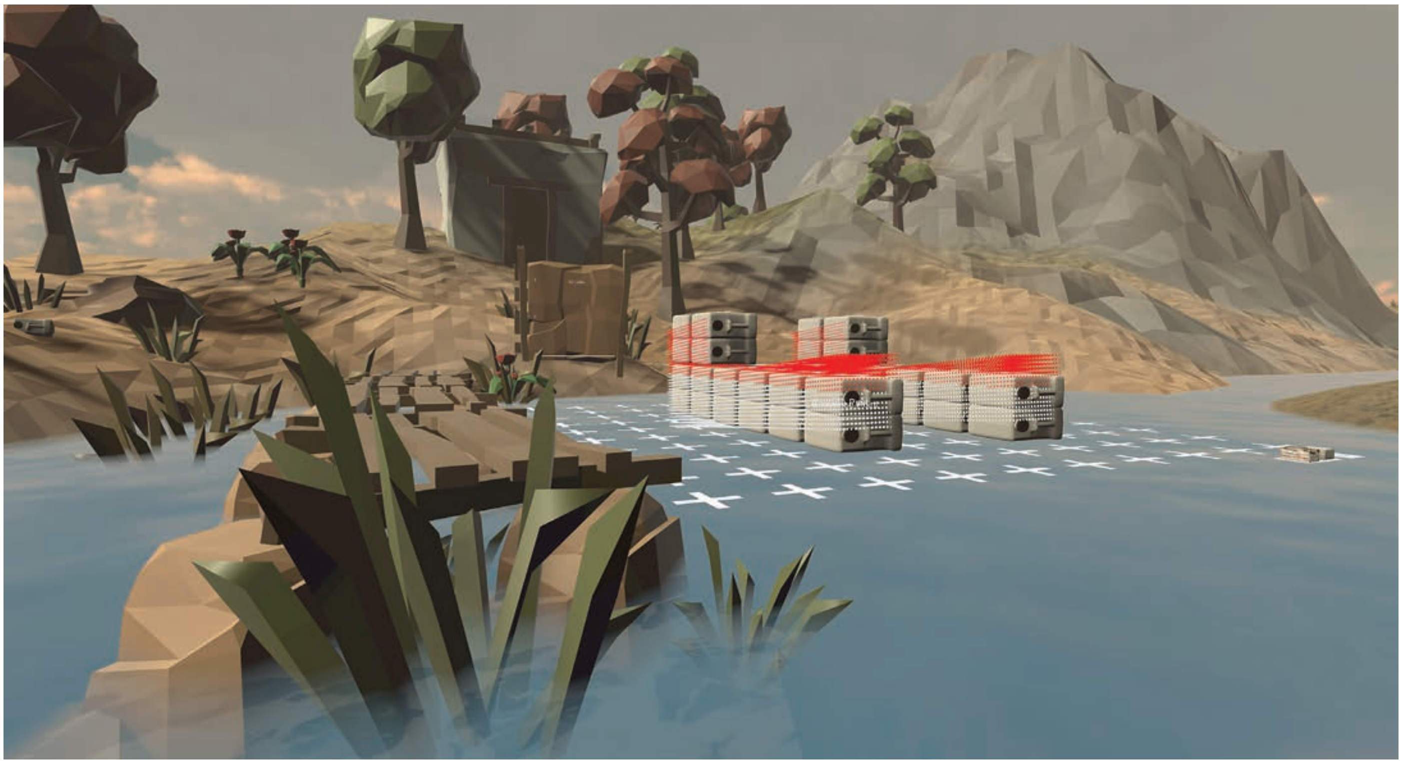

Figure 2. Global view on the stability game environment

work is implemented at this very moment, not only aimed at sensors (measurement), but also at actuators (control and operation). This cloud-based environment does not only provide signal communication, but also processing and presentation, see figure 1.
Simultaneously in the second work package, the current application of operational data in shipping is investigated as part of a PhD research. Furthermore, a student Business Analytics from the VU Amsterdam is performing his master thesis research based on operational data provided by a selection of the participating partners. The goal is to investigate possible future opportunities within existing datasets. The combined results of work package one and two will provide input and direction for work packages three and four, which will commence somewhere in the course of next year.
Work package five concerns knowledge development for educational purposes. Being in a technological educational environment, MIWB has two missions: researching new technologies and applications, and converting those into educational programmes. One manifestation of this task is the new BSc minor "Advanced Engineering Tools for ShipX", where X is shorthand for design and operation. This minor commenced in September 2020, and is currently only available to MIWB students. Yet, the aim is to offer this minor from 2021 as a postgraduate course to professionals in the field.
The course is concentrated on engineering tools and methods that have emerged in the (construction) industry over the past decades. Because quite some tools are implemented in software, the minor starts with a programming course. However, the emphasis of the minor is not on programming, but on algorithms and algorithmic thinking. For programming languages come and go, while smart algorithms remain to serve us for centuries. Subjects are:

- Programming in Python. There are (too) many programming languages in circulation, while in essence they all do the same thing. Seen from a distance, one language is not better than the other, just like Spanish is not better or worse than French. We have a preference for elegancy, which causes 85 per cent of the languages to be ditched. Other indicators are popularity and low-cost, and, predominantly, the availability of a wide collection of pre-programmed libraries with all kinds of utility functions. Based on these criteria Python has surfaced.
- Numerical methods in engineering, notably maritime applications of differential equations and statistics. Not from a theoretical background, but practice based.
- Linear and non-linear optimisation. With application in for instance optimal cargo intake, route planning and just-in-time arrival.
- Data and shape modelling. Seen from a distance, this combination may seem odd, however, the two are different applications of the same tools. Data modelling where for example a regression formula or another meta model is fitted through data points. And ship hull shape modelling where similar tools are used to fit a smooth hull surface through measured points. Another subject is the wide variety in (ship) shape representations, the corresponding file formats and consequently the disappointingly low rate of interoperability.
- Application of computational fluid dynamics (CFD) in the ship design practice, with hands-on training in one of the popular commercial CFD tools. The goal of the course is to teach the student

Figure 3. Detail of the stability game, with the stability curve (GZ-curve) carved in stone.

the skills to responsibly outsource and assess CFD calculations.

- A brief introduction into data science, its expectations and its limitations. With guest lecturers from maritime and non-maritime backgrounds.
- A research assignment, where the student demonstrates the ability to apply the learned tools in a practical maritime application.

'A nice enrichment of the existing curriculum,' says Jan de Jonge, MIWB lecturer about the minor. One of the first students taking this minor adds: 'A step towards the future, in which we learn to discover the thinking behind the automation algorithms'.

Stability game

A major reason for MIWB to have initiated the TODDIS project is to convert the newly gained knowledge into student research projects as well as bachelor and master study programmes. However, those programmes are intensive, so in order to create time for a new course, other courses should either be abolished or taught more efficiently. A candidate for rationalisation is the course on ship stability. This choice may be somewhat unexpected, for one of the authors is a renowned stability expert. Yet, our aim is not to drift away from stability as such, on the contrary, the idea is to focus on the essentials of stability. Quite a challenge, because our rich maritime history obfuscates the essence of stability. Which is – limiting ourselves to the timeless action of forces and moments under heel, as reflected in the IMO Intact stability code and many other stability rules and guidelines – the perpendicular distance between the downward force through Centre of Gravity, and the upward force through Centre of Buoyance. Is that all there is? Yes, that's all there is my friends, and let's keep dancing, to paraphrase the 1969 Peggy Lee top 40 hit.

Unfortunately, the clear view of this foundation has been taken away from us because calculating stability was once so time-consuming. For this reason, we have been buried with all kind of side dishes, such as Simpson's rules, moment to change trim, GM = KM – KG, tonne per centimetre immersion, et cetera. Not incorrect, once useful, but now obsolete because arithmetic is not a limitation anymore. The *raison d'être* of the metacentric height is its linear approximation of GZ – the righting lever – around zero degrees. But why use an approximation if an exact computation is so easy to obtain? Scribanti provides a higher-order polynomial approximation around zero degrees. Again, why approximate? By the way, both are special cases of the Taylor expansion, a generic tool taught over the past fifty years at first year university math courses. Plain stuff, so there is no need for specific traditional naval architectural concepts or notions. So, if we scupper such forlorn concepts, then we return to the basics; the distance between downward and upward forces, depicted as function of heel in the GZ-curve. That's all there is.

> New tools need to be ruggedised and made fit for practical application in the maritime industry

Until now, this spirit on this subject has been a bit destructive, however, if old forms and thoughts have died, what to use as replacement in the education in stability? Experiments with a physical model have been considered, at model scale in a water basin, or with larger models on open water. Besides the human risks involved with open water experiments, a physical model has the drawback that the essence of stability, the effect of the forces, is not visible or otherwise perceptible. So, another instrument for displaying these notions was sought, and found in the guise of a computer game.

The scenario of the game is a group of uninhabited islands, on one of which a group of shipwrecked people is washed ashore. Wood, rope, canvas and jerry cans are miraculously available there, and can be used to build rafts with which one can sail to the other islands, where food and other useful things can be found. In this way, one is challenged to design a sailing raft and, at the cutting edge, to undertake the voyage, knowing that bad weather could come. This then starts as a skill game, but becomes educational when the stability forces and stability curve are also shown at a certain stage, as augmentation to the game's virtual reality. The whole idea behind this game is that from experiencing the primary behaviour of the raft and this additional play of forces, an established concept of stability arises in the student. Obviously, afterwards the theory will have to be elaborated a bit more, and one will have to practice with calculations, but first comes the understanding and only then the math.

Important building blocks of the game – which is being developed with support of Stichting Verolme Trust – are currently completed, such as the entire scene with islands, a "construction site" for assembling rafts from jerry cans and the underlying stability calculator. Completion of the first playable game version is expected later this year. Figures 2 and 3 give an impression of its appearance.

Concluding, with both TODDIS and the Stability Game, MIWB, in close collaboration with the industry, pulls the rope on preparing the next generation of naval architects and marine engineers for the digital transition at hand.

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