

Simulating Bending Failure of Ice using Smoothed Particle Hydrodynamics

The offshore industry is a conservative industry, sticking to rigid best-practices and reluctant to try new techniques. A promising new technique that hasn't found much adoption in the offshore industry is SPH. This thesis aims to improve the reach and use of SPH within the offshore industry. With an abundance of world's unexplored hydrocarbons located in the Arctic Region, 18%, ice-structure interactions (ISI) are set to increase. Modelling these ISI requires complex dynamics and SPH can model these ISI dynamics without extra treatment.

SPH works by interpolation of a set of neighbouring particles using a weighing function, see Figure 1. The particle being interpolated is shown in red, the neighbouring particles in black, and the kernel (weighing) function in green.

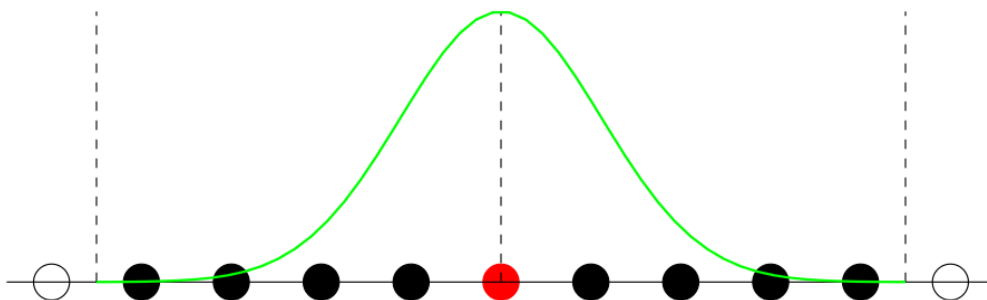


Figure 1: 1D SPH

This modelling technique offers many advantages over conventional rules-of-thumb, Finite Element Modelling (FEM), and Finite Volume (FV) methods. SPH is a particle based method, thus, uniquely suited for problems with large displacements, or discontinuities.

However, in the standard, weakly-compressible (WCSPH) method spurious pressure fluctuations and particle clustering can occur. By implementing the plethora of correction methods and equations present in literature, such as kernel corrections, incompressible variants, or density corrections, these drawbacks can be circumvented and a robust framework can be formed.

An implementation of WCSPH that focuses on adaptability and flexibility is presented in this work. The flexibility of the implementation allows future researchers to focus on the core of their research, only changing the equations they are interested in, instead of implementing all the required equations for a full SPH simulation. A validation study of the implementation has shown that it matches closely with existing implementations and real-world results.

The mathematical model developed in Keijdener, Hendrikse, and Metrikine (2018) and Keijdener and Metrikine (2014) is implemented in the proposed WCSPH implementation. Comparing the results shows close agreement for the breaking length and its dependence on the ice velocity. However, significant differences are present in the time until failure. Despite this discrepancy, this work shows the possibility of combining solid mechanics with SPH, and validates the integration method, solver, and SPH model.

In the future I expect the use of SPH to grow in all industries, the offshore industry included. SPH is an extremely promising technique with many advantages over conventional techniques. As shown by the comparison with Keijdener, Hendrikse, and Metrikine (2018), SPH can approximate dynamics without extra treatment and is, therefore, a valuable tool for the offshore industry.