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TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Synthesis-Based Engineering in Storm Surge Barriers

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SUPERVISORY CONTROL SYNTHESIS

Supervisory control synthesis (see Fig. 1) enables engineers to concentrate on what the system must achieve, rather than how it operates. This makes it a natural fit for industrial applications. In recent years, supervisory controllers have been successfully applied to bridges, tunnels and locks, in collaboration with Rijkswaterstaat.

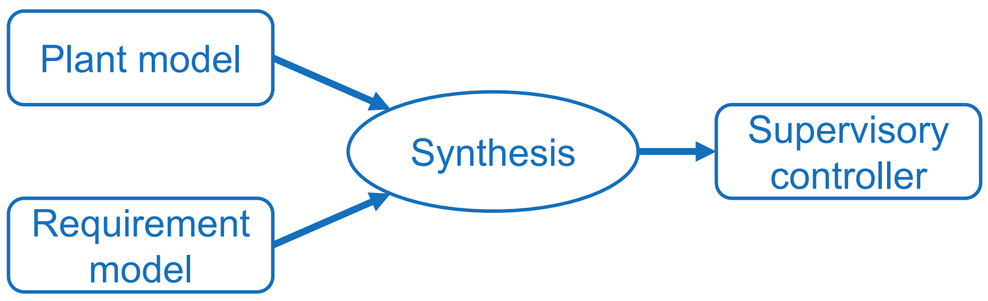


Figure 1: The synthesis process.

STORM SURGE BARRIERS

Currently, steps are being taken to apply supervisory controllers to storm surge barriers as part of the STORM_SAFE project. Storm surge barrier control faces three main challenges:

- **Reliability**: System failure of a storm surge barrier has large socio-economic consequences. As a result, it is even more important to ensure that software is reliable: emphasis should be placed on the absolute avoidance of failure states.
- **Variability**: Due to differing environments and design constraints, storm surge barriers are essentially all unique prototypes (see also Fig. 2). As a result, there is no one-size-fits-all solution for the control of storm surge barriers. Model assemblers, as built for locks and bridges in previous research, do not look promising.
- **Multi-functionality**: Most storm surge barriers have simple actuators to open and close. However, the reason for operating the barrier is complex – depending on many different inputs. This complex reasoning must be captured in the supervisory controller, but a framework for this is lacking.

Figure 2: Highly varying barrier designs.

DANISH COASTAL AUTHORITY

In collaboration with the Danish Coastal Authority (DCA), solutions to these challenges are being investigated. In a first step, the components of a real storm surge barrier system at Hvide Sande are identified and modelled. Requirements are defined for supervisor synthesis. Then, an interactive simulation is prepared (see Fig. 3) to show controller behavior to infrastructure providers.

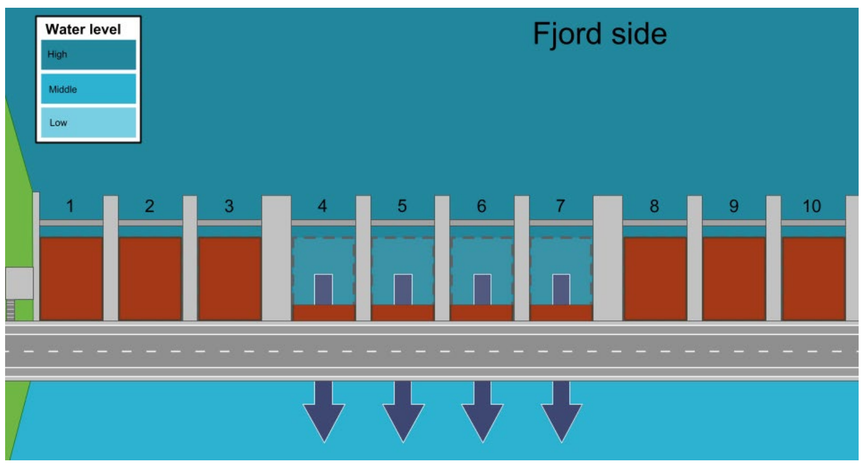
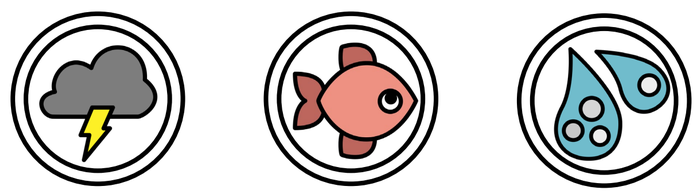


Figure 3: Preliminary simulation of the barrier at Hvide Sande.

OPERATING MODES

The challenge of multi-functionality could be addressed by introducing modes. When the control architecture is divided into modes, it becomes much more obvious to express when certain events are not allowed, contributing to more meaningful and human-readable requirements. 8 operating modes of DCA's storm surge barrier have been identified (see Fig. 4 for examples).



(close all gates) (open >=1 gate) (open all gates)

Figure 4: Various operating modes and their desired behavior.

The modes are not modeled to be exclusive: any combination is in principle allowed by the supervisor. However, it is possible that two modes are contradictory and cannot be satisfied at the same time. In that case, no useful behavior would be possible anymore, except deactivating a mode. This leads to non-progressive behavior.

To properly include operating modes, the notion of progressive events is explored. Activating or deactivating a mode is then considered a non-progressive event. An alteration to the synthesis algorithm that supports this change is being investigated.

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