HavObservatoriet

Narrative

HavObservatoriet was an inquiry into new ways of interpreting and visualising the physical processes that impact on behaviours and dynamics of ocean waves. The project constructed a physical ocean observatory that digitally simulates the wave dynamics of the oceans surrounding Denmark in real time, using real time ocean forecast data supplied by the European Centre for Medium Range Weather Forecasts (ECMWF). Each geographic position of spectral data simulates the amplitude of waves at every wavelength and in every direction as one single circular image that envelops the viewer in a combined statistical model of the behaviour of the sea surface.

The project is constructed as a permanent circular open-air 'wave observatory' in Vejle Klima Park, a landscaped harbour area, designed to protect the city of Vejle against flooding. The observatory creates a public space within the park, sheltered from the wind and connected to the power of the ocean.

The project converts the spectral data into an animated simulation of the ocean surface which is rendered using a non-photorealistic particle-based rendering system. The panoramic image of the sea that surrounds the viewer is displayed at 1:1 scale: a one-meter-high wave will appear one meter high in the observatory. Because the screen wraps around the viewer, a wave approaching from one direction will 'wash' over the observatory and disappear in the opposite direction.

HavObservatoriet was developed in collaboration with Joshua Portway and Jean Bidlot, Senior Scientist at the European Centre for Medium-Range Weather Forecasts (ECMWF) and further supported by Matthieu Chevallier, Head of Evaluation at ECMWF. It was the first of a series of artworks commissioned by Vejle Municipality and The Danish Art Foundation with a focus on water as a future challenge and potential. The project was supported by regional renewal funds of the Danish Social and Housing Authority and Sheffield Hallam University.

(303 words)

Method

HavObservatoriet was designed as a 3m high, 7m diameter circular steel building which contains a giant panoramic circular screen

Methods
Software development

To develop the ocean wave simulation we worked with ECMWF (who generously provided access to their data free of charge), and specifically with senior scientist Jean Bidlot, who helped us to understand the intricacies of ocean wave spectra, and provided us with example data,
Much of the surface generation software code was based on Christopher Horvath's paper Empirical directional wave spectra for computer graphics.
In developing the project we were acutely aware of the power requirements of running a large LED screen for long periods of time. In response we developed a rendering technique that only requires a small proportion of the screen to be illuminated at any one time. Most of the image is black, and so requires very little power. In addition, the entire display is responsive to ambient light conditions and dims the image when possible to save power.

The animation and rendering systems were proptotyped in Houdini, and then written as shaders in HLSL and Unity. We wrote the streaming data processing pipeline for converting the ECMWF forecasts into animation data in Scala.

Image: Jean Bidlot : example wave spectra from the seas around denmark

Image: An early prototype of the particle based wave rendering system
Images: Early previsualisations of the structure, and cutaway view of the construction

Construction
We previsualised the building and screen characteristics using a parametric system developed in Houdini and exported as USD for VR visualisation. We did the detailed structural design and engineering analysis in Solidworks, and later re-modelled it in Fusion360 for manufacturing.
The fabrication of the building itself was done by InMetal a/s a local metal fabricator who were able to do the precision laser cutting and bending work required for the steel design.
The screen is supplied by Immediad Group. It is a based on a flexible 250mm x 250 mm module, with 2.9mm pixel pitch. Immediad were one of the few Danish suppliers able to provide a flexible display - essential for a curved screen.
Engineering consultancy was provided by Leonardo Battezini at OJ Rådgivende Ingeniører A/S who verified that our design wouldn't sink into the swamplike soil of the Klimapark.
T Jarle APS, Winther & Trolle APS, HETEK A/S, A/S, Sonny Olesen Smede og Maskinteknik