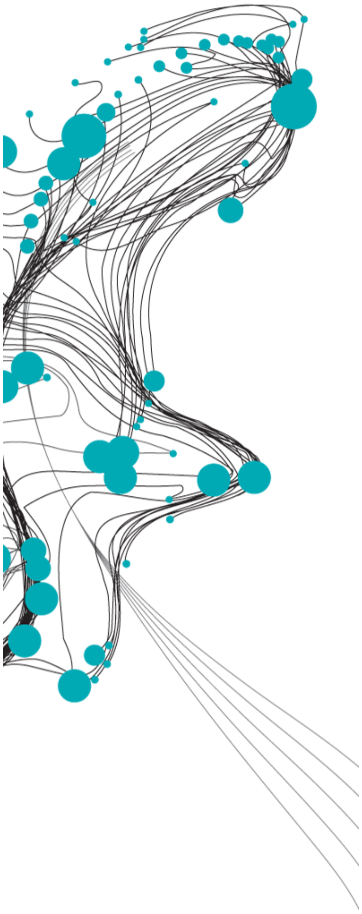
Visualization and measurements of the flow around scaled beach houses



Coastal dunes are crucial elements of the flood defence system of the Netherlands. Windblown sand transport plays a key role in their morphodynamics. Currently, arrays of beach houses are arising in front on the dunes and they act as obstacles in the flow field. It is unknown what effect this has on the evolution of the dunes. The houses are bluff bodies, which are the opposite of streamlined bodies. In this thesis bluff body aerodynamics are reviewed. Bluff body flow is characterized by complex flow structures, e.g. vortices, which arise due to flow separation. In order to understand the effects of the beach houses on the evolution of the dunes it is necessary to first study the flow topology.

This study presents the development of a quantitative flow visualization setup using relatively simple devices to study this flow topology. It comprises a high speed imaging system using 2 moderate speed cameras and a special purpose control system. The high speed imaging system is capable of capturing image pairs with a time interval between 1.5-80µs and illumination times can be varied between 800ns-80µs. Therefore it can be used for a wide velocity range.

To visualize the flow fields, a tracer particle is required. The feasibility of using smoke as a tracer particle is investigated. The smoke was illuminated by the means of a laser sheet. It is found that in a configuration where two cameras are used smoke is not a suitable tracer particle for quantitative flow visualization. Because the two cameras view the scene from a different angle, both cameras see a different portion of the smoke outside the light sheet. This induced artefacts in the data which could not successfully be removed.

To translate the data obtained to a velocity field, two algorithms have been evaluated. The performance of a particle image velocimetry (PIV) algorithm was compared to that of an Optical Flow estimation (OFE) algorithm. A PIV algorithm calculates a correlation matrix between interrogation areas of two consecutive images. OFE relies on a global method and tracks regions of constant intensity in two consecutive images. Additionally it assumes smoothness of the flow. To assess the effectiveness of the two algorithms, a smoke image was warped with a known displacement field and the relative error was calculated for the PIV and OFE calculation. The OFE algorithm outperformed the PIV algorithm. The calculation resulted in much smaller errors and much denser vector fields. However when using OFE on the real data it tends to overestimate the velocity values.

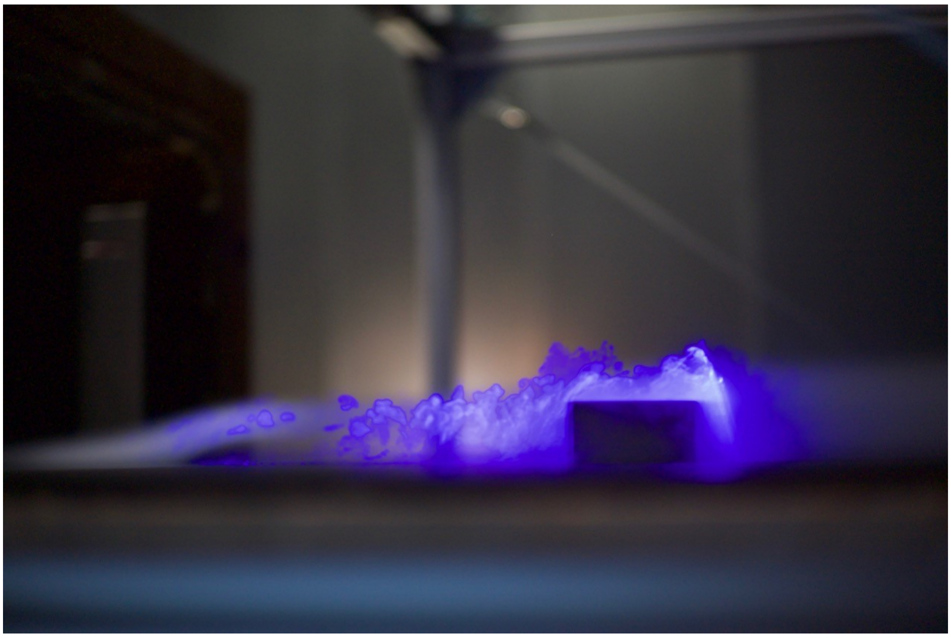


Figure 1: Smoke visualization of the flow around scaled beach houses. Illumination is by laser light sheet. Photo by Patrick Jonkman.

Elise Leusink

Graduation Date:
12 December 2016

Graduation committee:
University of Twente
Dr. K.M. Wijnberg
Dr. Ir. R. Hagmeijer

UNIVERSITY OF TWENTE.