VIDEOIMAGERY TECHNIQUES AND MULTIVARIATED PARAMETER ANALYSIS TO DEFINE 3D MAPS OF VULNERABILITY

Gómez-González, R. , Molina, R. and Castillo, C.
Ports Laboratory of the Politechnic University of Madrid & University of Castilla-La Mancha

Puertos del Estado
CÁTEDRA PABLO BUENO Ingeniería Civil del Mar
UCLM Universidad de Castilla-La Mancha, Escuela de Ingenieros de Caminos Canales y Puertos de Ciudad Real

Introduction & Objectives — IO1

Objective: To develop a methodology to obtain 3D maps of vulnerability of a marine structure

Videoimagery techniques
+
Statistical analysis
= Information of **vulnerability evolution** not evident to the naked eye

3D maps **show** the behaviour of breakwaters making the task of **conservation** and **maintenance** easier and improving **damage prediction** for a better management during the useful life of the structure.

This methodology is **complementary** to existing **theoretical formulas** to evaluate damage evolution.

Materials & Methods — MM1

This methodology is based on the application of videoimagery techniques to obtain countable information about the interaction between waves and structure that, in this case, is a rubble-mound breakwater.

On one hand, **time stack analysis** allows determining the ***incident wave angle***; when a control section is located perpendicular to the crown of the structure (BB') and a time stack is generated, it is possible to obtain wave series and thus, wave heights and wave periods. This can be used to calculate ***Run-up*** and ***Run-down***. If the control section is located at the crown of the rubble-mound breakwater, a Peak Over Threshold method can be employed to calculate ***overtopping***. Once the overtopping time series is known, a ***flow estimation*** and a map of the ***most exposed areas to overtopping*** can be obtained.

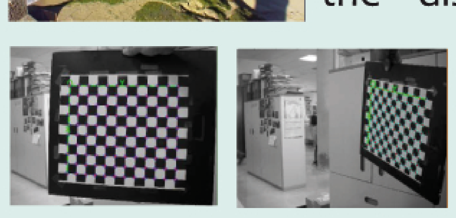
On the other hand, **statistical analysis** allows obtaining bidimensional ***maps of energy dissipation*** for each sea state thanks to ***RGB variance*** calculation and overlaying them in time, maps of vulnerability. When ***RGB mean*** is obtained, the ***average phenomena*** is identified directly. The big advantage is that the sea level can be measured. If the known components of the sea level are calculated, setup (which is not still well known) is straightforward.

Main tool : video system, which technology is cheap, easyworking and requires a low maintenance.

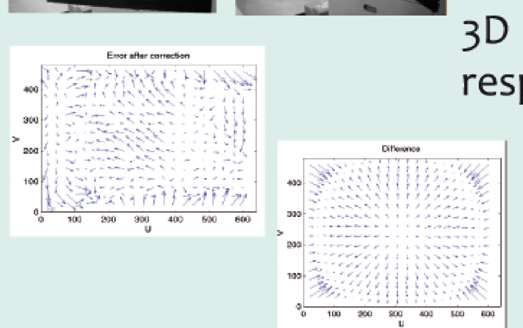
Tools & Concepts: ZEUS Project

Image acquisition: Frequency rate 10-60 Hz.
Recording time: 1 h

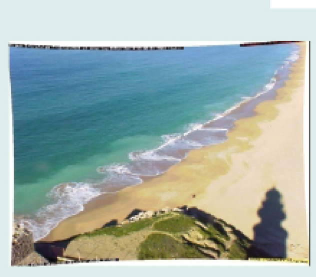
Distorted image
It is not possible to obtain countable information from the image because the distances are not constant.



Camera calibration
To determine the geometric and optical characteristics of the camera and the 3D and orientation of the image with respect to a global coordinate system

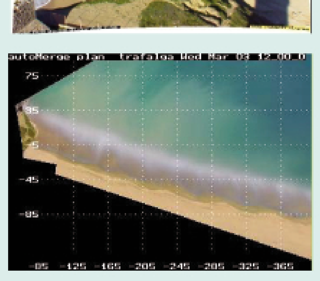


Aberration Correction
To eliminate the different distortions from the image as spheric, astigmatism, comma, distortion, ...



Undistorted Image
Lens distortions from the camera have been eliminated.

Image restitution
It is the process to transform the image to see it from a cenital view, where the distances are real.



Restored Image

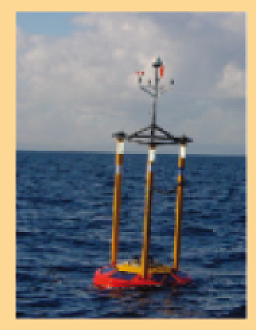
Image information analysis — Mean, Variance, Time stack

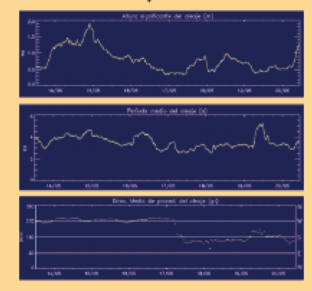
Methodology

M1. Instrumental Wave Series — M1

1.1. Off-shore (>200 m depth)

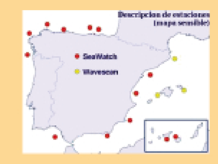
Each Δt, sea state





Hs (Δt)
T (Δt)
Φ (Δt)

Off-shore



Spanish off-shore buoys conform REDEXT and are located more than 200 m depth
http://www.puertos.es/es/oceanografia_y_meteorologia

(Hs, T, Φ) REDEXT

Correlation — Calibration

1.2. On-site

Time Series of:
Wave height **Hs** (t)
Period **T** (t)
Direction **Φ** (t)
Currents ...
Frequency rate 1-4 Hz

Each Δt, sea state → Hs (Δt), T (Δt), Φ (Δt) → (H, T, Φ) ON-SITE

Calibration
The information provided by on-site instrument allows calibrating the off-shore instrument to local conditions

Theoretical Formulation →

M1.1. Analytical formulation of **Flux-Structure Interaction**
M1.2. Theoretical formulation of **damage evolution**
M1.3. Theoretical Run-up

Correlation
Calibration of the off-shore instrument can be made through the correlation between the parameters from the on-site instrument and the off–shore instrument

→ To M3

Conclusions [1.1 + 1.2]

M2. Cameras — M2

Δt, sea state
↓
Video records to do

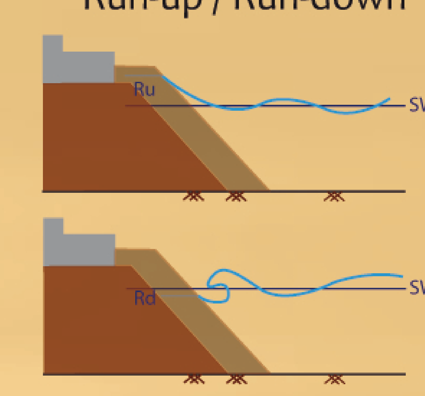
Time stack analysis
Statistical Analysis

Statistical Analysis
RGB Mean: Obtain the average phenomena
RGB Variance: Identify areas that are changing in time

Example applied to a Rubble-mound breakwater

What is Time Stack?
Time series of pixel intensities

Run-up / Run-down



Theoretical Run-up

Two different source of information to know in depth the phenomena and its associeiated consequences

Experimental Run-up

2.1. Time stack analysis

Original Video

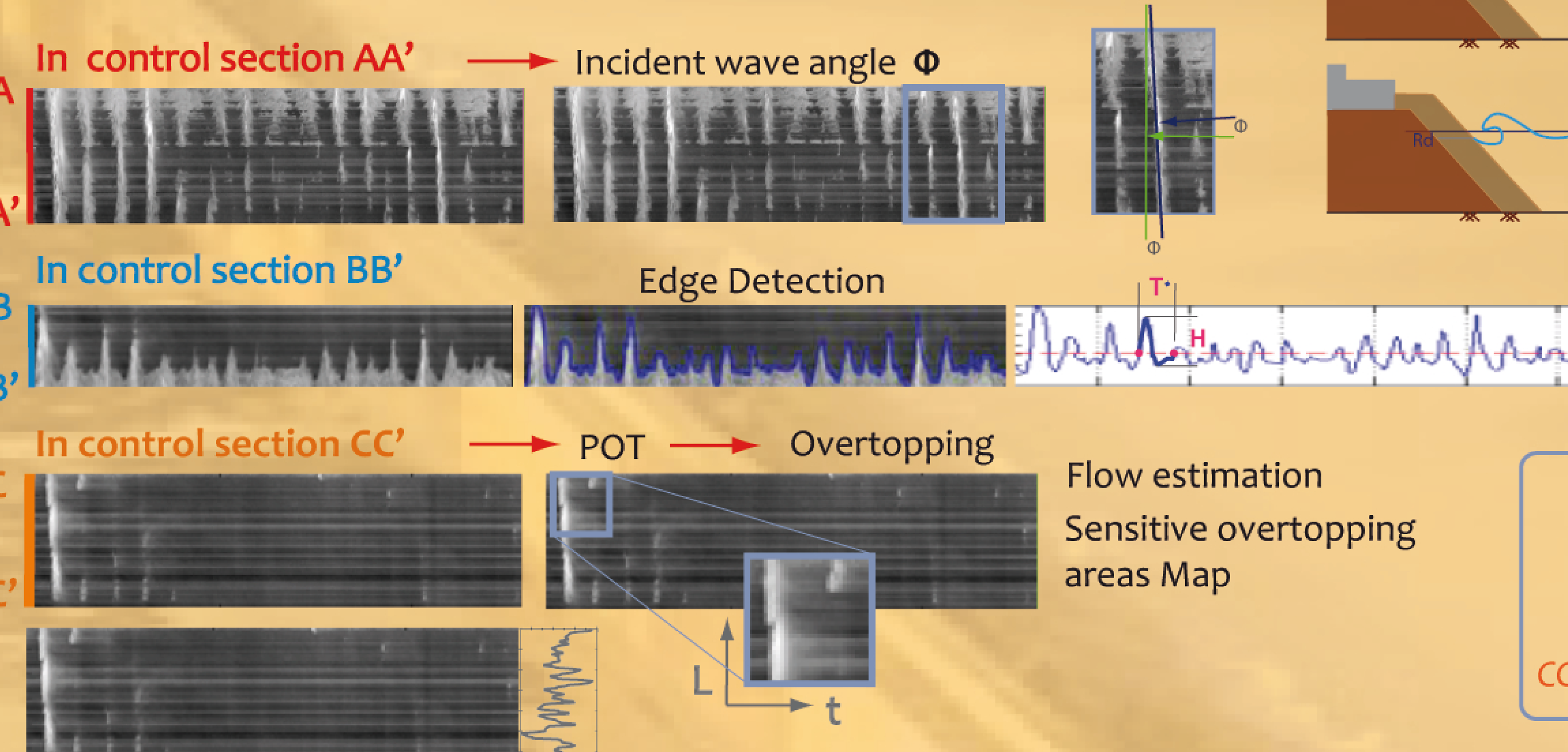
Selection of **control sections**

In control section AA' → Incident wave angle Φ

In control section BB' — Edge Detection — Period, Wave height

In control section CC' → POT → Overtopping

Flow estimation
Sensitive overtopping areas Map



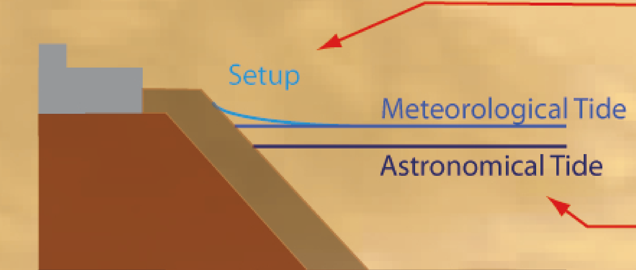
Conclusions [2.1]
AA': Incident wave angle Φ
BB': Experimental Run-up
CC': Flow estimation
CC': Sensitive overtopping areas Map

2.2. Statistical Analysis

RGB Mean

Sea Level = Mean Water Level + Setup = Astronomical Tide + Meteorological Tide + Setup

Different levels — Can be obtained by...



Cameras
Instrumentation
Prediction

RGB Variance

Energy Dissipation
Related to color dispersion in turbulent processes
Turbulence = White

→ Intensity color record in each frame →

PIV + Energy

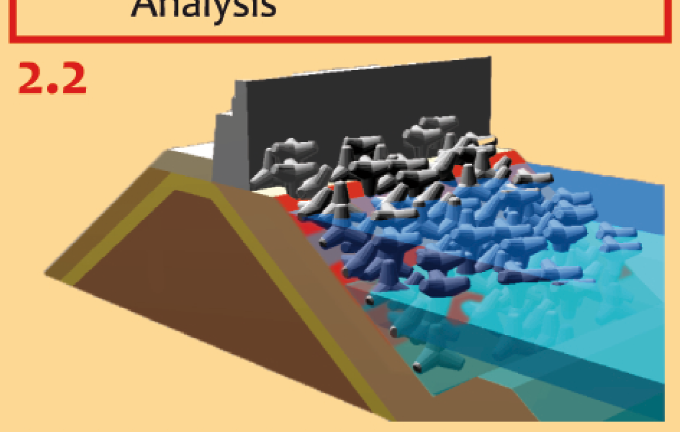
Energy Impact Distribution

Conclusions [2.2]
Setup level is obtained
Energy dispation areas are located and its evolution in time is known

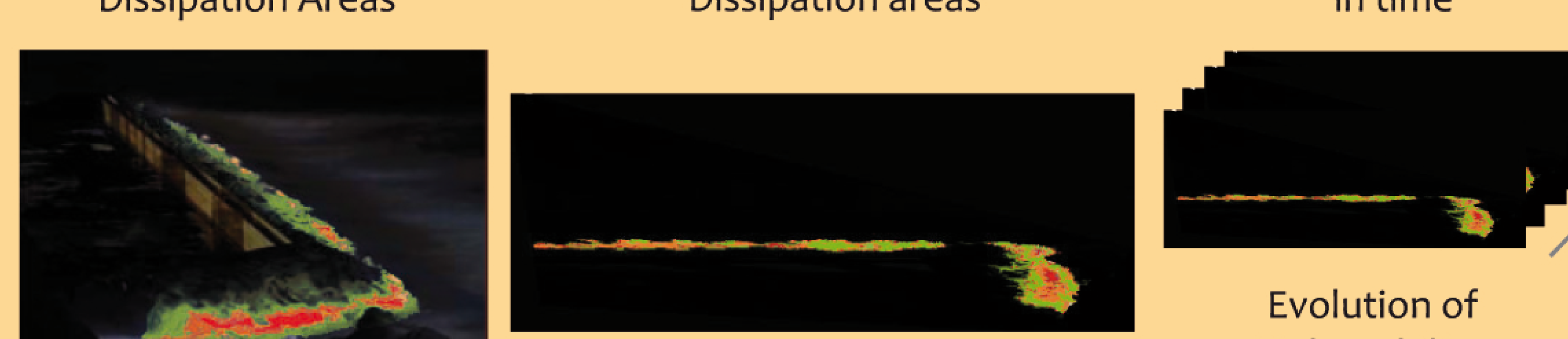
M3. Conclusions — M3

Energy Dissipation Analysis + Sea Level

2.2



Frames of Energy Dissipation Areas → Map of Energy Dissipation areas → Frame Overlaying in time



1.2

Evolution of Vulnerability Maps + Theoretical formulation of damage evolution

Complete Information of Damage Estimation: Graphic Information about Vulnerability and Quantitative Information from theoretical Models
M1+M2

Instrumentation 1.1 +1.2		Time Stack Analysis 2.1		M1+M2
Incident wave angle	+	AA': Incident wave angle	→	*Instrumentation Calibration*
Theoretical Run-up	+	BB': Experimental Run-up	→	*Run-up calibration*
		CC': Flow estimation	→	*Sensitive overtopping areas Map* (M2)

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Contact

Rebeca Gómez-González: rgomez@caminos.upm.es Rafael Molina: rmolina@caminos.upm.es
Carmen Castillo: MariaCarmen. Castillo@uclm.es