Tool - Argus Bio monitoring station

High-resolution monitoring of tidal flats is crucial for estimating the impact of nourishments and other engineering measures. This would require regular visits of project sites to assess e.g. changes in bed level, the number of birds and colonization by benthic animals or vegetation. Most tidal flats however are difficult to access, especially in more difficult - but no less relevant - weather conditions. Moreover, visitors inevitably disturb the site.
It would therefore be preferable to have a remotely-controlled and continuously operating monitoring systems to provide information about the development of intertidal areas. The ArgusBio station is such a system, combining proven Argus technology for the monitoring of (beach) morphology with novel high-resolution observation techniques for biota.

General Tool Description

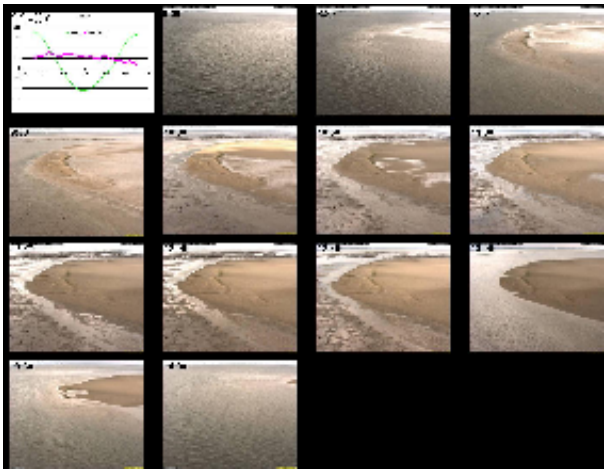
General Tool Description

Context

M
o
n
i
t
o
r
i
n
g
t
h
e
m
o
r
p
h
o
l
o
g
i
c
a
l
a
n
d
b
i
o

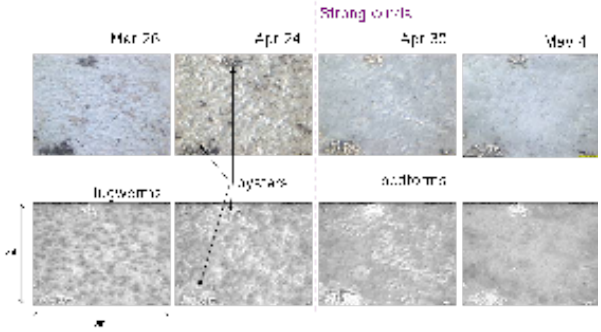
logical developments of intertidal area is crucial to understand th

Fixed view 'traditional' Argus cameras overlooking the Galgeplaat nourishment



A full tidal cycle registered by the leftmost Argus camera

efunctioningofthebiogeomorphologicalsystemand,consequentl



Images from the multi spectral camera before and after a period with strong winds. Changes in bed forms and algae cover are clearly visible.

An image from the Pan/Tilt/Zoom camera, showing two birds.

y, to effectively manage this system. This applies not only to management at a relatively short timescale, i.e. months to years, to assess direct impacts of human activities (e.g. nourishments, structures), but also at a longer timescale, i.e. years to decades, to assess coastal safety and to comply with regulations such as the EU Bird- and Habitats Directives.

Traditionally, monitoring requires regular visits of project sites in order to assess e.g. changes in bed level, the number of birds, or the (re)colonization by benthic animals and vegetation. Most tidal flats, however, are difficult to access and therefore expensive to visit, especially in averse - but no less relevant! - weather conditions. As a consequence, the monitoring frequency may be too low to capture the relevant dynamics of the system. Furthermore, visitors can physically disturb the site or scare birds. Also, traditional monitoring methods tend to focus on one system component at a time, i.e. birds are counted at a different time than benthos is sampled or the bathymetry is measured. This makes it more difficult to interpret the data in terms of relations between these components.

As an alternative, remotely controlled and continuously operating monitoring systems can provide valuable, comprehensive and high-resolution information about the development of intertidal areas. This was the reason to develop the ArgusBio monitoring station.

Tool description

The ArgusBio monitoring station uses multiple geo-referenced cameras to observe the environment. Listed below are the current layout and settings as used to observe the dynamics of the pilot nourishment on the Galgeplaat in the Eastern Scheldt, the Netherlands. Note that the system was built early 2009; nowadays cameras with better specifications are available at the same cost. Also note that different locations and/or different interests might ask for different equipment.

- 4 Traditional Argus cameras (fixed position, 1.2 megapixel) make time-exposures (pictures at multiple timesteps merged into one) every 3 minutes to observe changes in bathymetry, inundation time and surface soil moisture. The field of view of these cameras covers the nourishment and its close surroundings, i.e. an area of roughly 500 x 500 m. Due to the oblique orientation, the resolution close to the station is much better than farther away. The latter is too low to recognize birds, for instance.
- 1 Pan/tilt/zoom camera (security camera, 0.5 megapixel) that scans five areas of interest of 50 x 50 m, all 50-150 m from the station, every 15 minutes during low water. The main objective of this camera is the observation of birds from day to day and during a tidal period. Close to the station the resolution is even sufficient to observe lugworms.
- 1 Multi-spectral camera with one RGB-sensor (red, green, blue; normally visible light) and two NIR (near infrared) sensors pointed at a fixed area of 4 x 4 m very close to the station to observe macroalgae, diatoms and macrofauna. The NIR sensors enable the identification of chlorophyll-a, a component that distinguishes algae from other features such as a bare bed or bivalve shells. Images are taken every half hour, theoretically enabling the quantification of diatom abundance throughout a tidal period. So far, only daily values have been used.

All these cameras are fixed in waterproof housings on a 15 m high platform mounted on a steel pile of 1 m diameter, which was drilled 12 m into the sand. The station is also equipped with solar panels and batteries for power supply, a water level sensor, a lightning conductor, a thermometer, a computer for data acquisition and equipment for data storage and communication.

The data produced by ArgusBio are essentially geo-referenced JPEG-pictures (or movies), saved in the Argus-database together with information on time and camera settings. Interpretation of this data requires a substantial amount of human labour or algorithms for automated recognition. Tools have been developed for the automated recognition of shorelines, the detection of wet, dry or moist areas, birds and microphytobenthos (diatoms). See 'practical applications' for more information.

How to use

How to Use

An ArgusBio monitoring station can be used at various locations: coasts, bays, estuaries and rivers. One station can cover an area of which the size depends on the quality of the cameras, the required level of detail (i.e. the features under observation) and the height of the observation post. An ArgusBio station can be used for monitoring before, during and after construction activities, or for long-term monitoring.

Before a station is fully functional, the following steps need to be taken:

- Who wants to use the results, and for what? As data are scarce and monitoring expensive, there may be multiple users (possibly willing to co-finance the facility or to buy the data);
- Define the monitoring purpose and determine the spatial and temporal resolution accordingly: short/long-term, high/low spatial resolution (i.e. only morphology or also smaller biologic features), high/low temporal resolution;
- Determine whether a monitoring station provides more value than traditional monitoring; compare the expected costs and benefits of both options;
- Design a suitable structure (vibrations, durability, robustness, protection against vandalism, height for field of view) and select the

equipment (resolution, durability, power consumption);
- Arrange permits for e.g. temporary structures, working in or near protected areas or shipping lanes, communication equipment;
- Set up a storage system (database) for the images;
- Test the functioning of the entire system at a land-based testing location, preferably for a longer period of time and under difficult conditions (does it have enough power? do data connections and protocols work properly? do the indicators for malfunctioning work properly? can errors be corrected remotely?);
- Install the system in the field; take measurements for geo-referencing of images, position the sensors and cameras on the platform, test connections;
- Be ready to visit a couple of times for corrections; camera positions may have changed;
- Gather samples/data for validation of the camera observations, e.g. in-situ samples of diatoms and a traditional bird count from the station;
- Perform regular inspections and maintenance, 1-2x per year;
- Continuously analyse images to get results, and translate these results into understandable and meaningful information for the user(s).

After the desired operational period, which can range from several months to (possibly tens of) years, the station can be removed and be re-used at another location. Since ArgusBio is a modular system, specific components can be upgraded or added, depending on the requirements for the new location. Since new equipment may cause a discontinuity in the dataset and is likely to require new calibration measurements, upgrades can best be combined with relocation, unless there is an urgent need. The life span of an ArgusBio station strongly depends on the quality and durability of its components, as well as the local weather conditions. With good protection against rain, salt spray, lightning and bird excreta, most electronic components will last several years. Heat, cold, moisture and sudden power shortages likely shorten the life span of these components as compared to regular indoor use.

Practical Applications

Practical Applications

Tools and results

The data produced by ArgusBio are essentially geo-referenced JPEG-pictures (or movies). Interpretation of this data requires substantial human

For morphology
:

1. Automated shoreline mapping, which enables the reconstruction of the bathymetry from water level and wave breaking observations, lik
   normal Argus
   does. The small bed slope and the irregular shape of intertidal flats make mapping more difficult than along a sandy coastal beach. Res
2. Manual identification of wet, dry and moist areas. During the Building with Nature
   pilot nourishment project on the Galgeplaat
   , it turned out that the soil moisture content is relevant to (recolonisation by) macrofauna. Result: a map of predominantly wet, dry or mo

For birds
:

1. Argus feature mapper, which allows the user to pinpoint and identify a bird (or other feature) in the picture that is subsequently saved in
   Baldi (2010)
   .
2. An automated algorithm that counts the number of birds, based on short (10 second) videos. Counting and identifying birds manually is

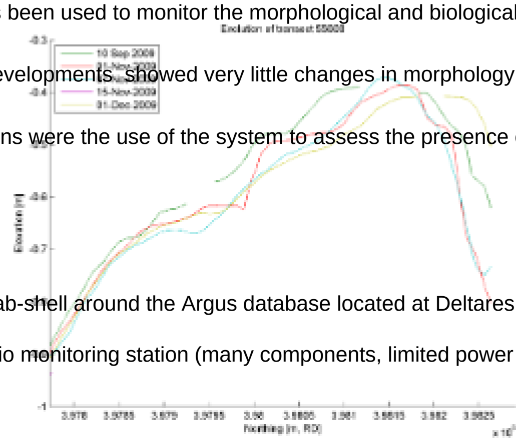
   If the algorithm would be developed further, limited identification of birds into classes such as gulls, small waders, large waders and gee

For macroalgae and microphytobenthos (diatoms)
:

1. An automated algorithm based on a trained neural network that determines a percentage cover for macroalgae, microphytobenthos and

Use and evaluation of results

The ArgusBio monitoring station has been used to monitor the morphological and biological development of the
pilot nourishment at the Galgeplaat
. The monitoring of morphological developments showed very little changes in morphology, which was confirmed by visual inspection and accur
Galgeplaat nourishment
 case). More experimental applications were the use of the system to assess the presence of macroalgae and diatoms over time using a multi-sp



Practicability

Most algorithms are part of the Matlab-shell around the Argus database located at Deltares, which is under license from Oregon State University

Due to the complexity of the ArgusBio monitoring station (many components, limited power to supply all components simultaneously) and the na

Application

The ArgusBio monitoring station can be a useful tool in situations where high-resolution data in space and/or time are required, or for projects wh
the Galgeplaat nourishment
 and other Building with Nature pilots). Another advantage of ArgusBio is its possible application at remote locations. Due to the effort related to i

Application provides the most valuable information if the station is operational well in advance of the execution of a project such that a represent

Morphological development of the nourishment (cross-section) monitored by ArgusBio

Lessons Learned

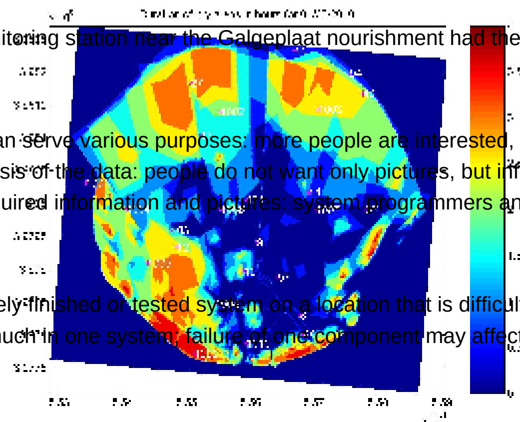
The application of the ArgusBio monitoring station near the Galgeplaat nourishment had the goal to monitor morphological changes and the pres

Do's:

- Select a test location that can serve various purposes: more people are interested, and permits might be easier to obtain;
- Secure budget for the analysis of the data: people do not want only pictures, but information. This translation takes a lot of work and req
- Communicate about the required information and pictures: system programmers and bird watchers do not understand each other autom

Don'ts:

- Do not install a not completely finished or tested system on a location that is difficult to reach;
- Do not try to integrate too much in one system; failure of one component may affect others.



https://publicwiki.deltares.nl/download/attachments/2392101/2dry-areas-01-03-2010.jpg?api=v2

References

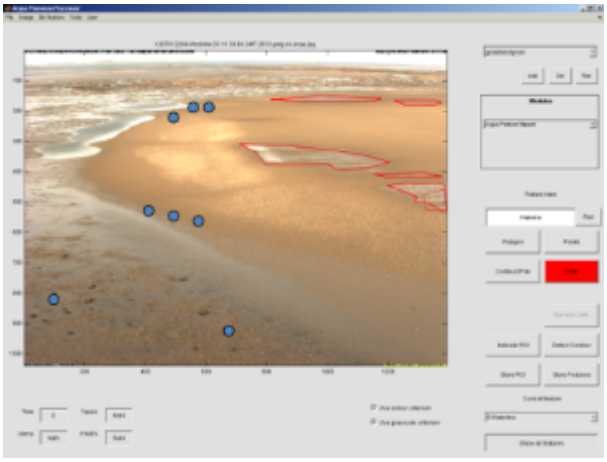
References

- Ye, Q., 2012
  . 'An approach towards generic coastal geomorphological modelling with applications', Delft University Institutional Repository
- Schwarz, C., Ye, Q., van der Wal, D., Zhang, L., Ysebaert, T., Herman, M.J.P., 2013
  . 'Impacts of salt marsh plants on tidal channel initiation and inheritance'

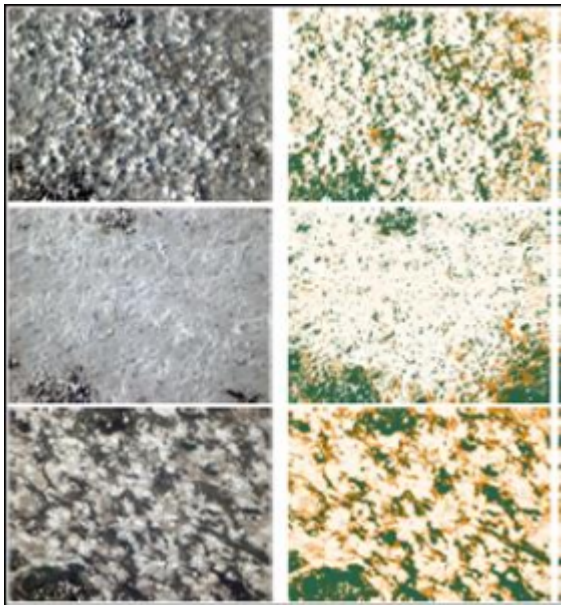
Relevant software

Delft3D:

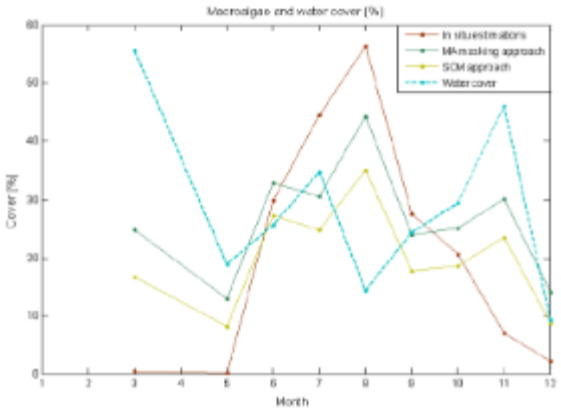
- Source-code
  (OSS account required)
- Delft3D-Suite
  , a precompiled version of the entire Delft3D-suite (including FLOW, WAVE, WAQ, MOR, PART, etc.).
- D-Flow FM



GUI of the Argus Feature Mapper. The dots indicate birds, the red lines delineate wet areas.



Macroalgae (green) and diatoms (orange) on a 4x4 m plot near the ArgusBio monitoring station. Top: March 2011, Mid: May 2011, Lowest: June 2011.



Percentage cover by macroalgae during 2011.