

Assessment of Coastal Hazards - CoastSAFE Alive Australia

Darrell Strauss¹, Rodger Tomlinson¹, Chris Lane² and Michael Blumenstein³

¹ Griffith Centre for Coastal Management

² CoastalCOMS

³ School of Information and Communication Technology, Griffith University

ABSTRACT

Reducing risks to life and property in the coastal environment requires monitoring of conditions to enhance our understanding of hazardous coastal processes. The CoastSAFE Alive project aims to develop real time assessment tools that provide safety indices and risk profiles for Australian beaches. This will build on previous assessments of Australian beaches by incorporating short-term changes to hazard ratings based on prevailing and forecast environmental conditions. Long-term monitoring of physical coastal processes provides the basis for the development of predictive models of our coastal environment. With a continuous data collection program in place, there is also the opportunity to provide real-time information to authorities charged with the duty of care of coastal users and management of coastal infrastructure. CoastalCOMS, Coastalwatch, Surf Lifesaving Australia, Surf Lifesaving Queensland and Griffith University are working on the development of assessment tools which integrate data collection and numerical methods to enable short-term forecasting of coastal processes which impact upon coastal users. Techniques being integrated range from video camera installations to complex artificial neural networks and shape detection algorithms.

INTRODUCTION

CoastalCOMS P/L in conjunction with Coastalwatch P/L, Griffith University, Surf Life Saving Queensland (SLSQ) and Surf Life Saving Australia (SLSA) have been awarded a \$1M Smart State Innovation Project Fund grant to develop a dynamic safety rating for beaches. The innovative technology being developed by the partnership will create a real time assessment tool to monitor risk profiles and provide a safety index for beaches around Australia. Successful outcomes will result in more accurate risk profiling of beaches, better resource management by Surf Life Saving and associated Councils and more importantly the prevention of unnecessary injury or death on our beaches. The result of this project will then be an assessment tool that will analyse beaches for environmental safety factors to assist appropriate personnel to manage resources that can minimise risk for the beach going public. The technology will be developed with the capability for use anywhere in the world.

RESEARCH OBJECTIVES AND METHODOLOGIES

There are three main focus areas for the research and development. These are investigation of the beach morphodynamics, algorithm development for automated analysis and the implementation of the system components. An overview of each of is provided below with a short summary of the approach to automating some of the processes.

Beach Morphodynamics

Beach state is a term used here to classify the morphology of sand bars in the surf zone. The widely used Wright and Short (1984) beach state classification scheme provides a means for monitoring changes to beaches in response to the environmental forcing of waves, wind, currents and tides. Because the driving forces are always changing the beach is in a constant state of change. The environmental forcing changes faster than the sediment transport so the morphology is rarely able to reach an equilibrium state. There is a requirement of any predictive approach to incorporate the antecedent morphology of the beach. The definition of the beach state transitions and the development of a beach state index will prescribe the dynamic variations inherent in a particular beach's safety rating.

A significant task is to establish a correspondence between the accepted beach state model of Wright and Short (1984) and the observed conditions obtained from video imaging. The emphasis will be placed on the time scale of transition between various states (Strauss et. al., 2006). Images will be classed according to both cross-shore and longshore morphological and hydrodynamic features. These features include the number of troughs present, dominant wave processes, surf zone shape and longshore trough variation. Wave height was found to be a controlling factor in determining the surf zone type that developed along with wind and wave direction. Rapid change in wind and wave conditions will also be identified and tested as possible triggers for beach state transitions.

Objective discrimination of beach state based on the variability in cross-shore surface pixel intensities derived from locally mounted cameras has demonstrated potential for long term monitoring of beach conditions (Browne et. al. 2006). These techniques will be appropriately refined and implemented in executable form for deployment to the CoastalCOMS servers.

Modelling of wave transformation into shallow water is performed using SWAN (Booij et. al., 1999). Boundary conditions for the model use wave data from the 0.5x0.5 degree global wave forecast model, WaveWatch III (Tolman, 2008). Waverider buoys located nearshore provide calibration data for the short term prediction of wave climate derived in this manner.

With the real-time capture of video images and analysis, beach condition maps for a snapshot in time will be produced. Neural networks have demonstrated potential for short term prediction of nearshore wave conditions in the absence of detailed bathymetric data (Browne et. al. 2006a). This approach will be applied to predict short time scale changes in beach conditions up to 7 days. This information will be correlated with beach safety data obtained from surf lifesavers to identify significant short-term, and potentially hazardous, changes in beach conditions.

Automated techniques and algorithms

The development of sophisticated algorithms will enable the automation of several key tasks required for the beach risk assessment and safety rating system. These include:

- Shoreline detection and measurement
- Breaking wave height analysis and forecasting
- Beach user counting
- Beach state analysis
- Dynamic risk assessment

Automatic shoreline detection

Automatic shoreline detection is an important component of the CoastSAFE Alive Beach Risk Assessment system. Apart from providing essential measurements and information pertaining to shoreline location, it serves as a base step for other components of the system. The process for shoreline detection uses image processing techniques such as noise removal and hue calculation for detecting the variation between the sand and the sea.

Breaking wave height

Another key element for the risk assessment is the measurement of nearshore breaking wave height. In order to estimate nearshore wave height, artificial neural network technology is applied to empirically estimate this parameter from global deep-water wave model output (Browne et. al. 2006a). The system is trained on captured video which is geo-referenced and processed using pixel intensity analysis to calculate the breaking wave height. This technique was developed during the course of a collaborative ARC Linkage project. An important step for future deployment of this component relates to tuning of the neural network and associated preprocessing of the data in a fully automated process.

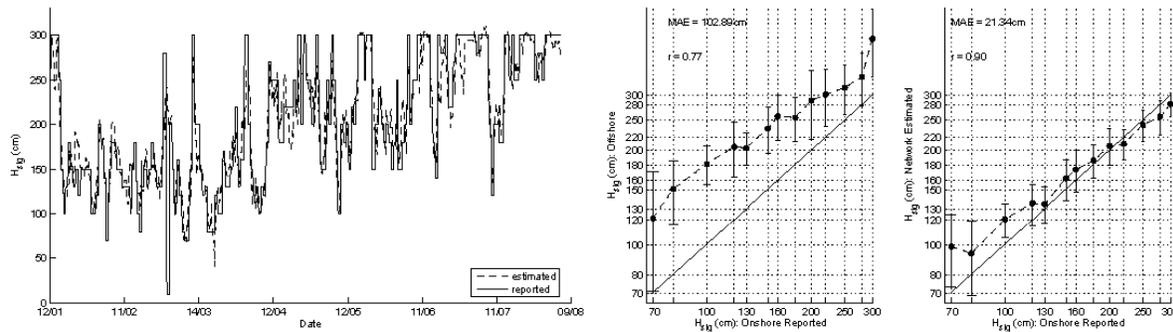


Figure 1. Example of neural network nearshore wave height prediction for Gold Coast (Browne et. al., 2006a).

Automatic beach user counting

Several image processing techniques are employed to detect and count beach users. These include noise removal, segmentation of objects defined as people from the scene and subsequently validating their shape based on the extraction of salient information from the object and performing automated classification. The output from the algorithm may be processed to provide the number of persons on the beach at a given time. This information is important for providing data to help predict future beach needs.

Aside from counting people, and analysing beach usage, automated detection of beach objects may also be extended to the process of tracking for the purpose of behaviour detection. This information may be used to determine the location of persons on the beach and then monitoring their behaviour with respect to potentially hazardous situations near the water. Algorithms to model human behaviour as they approach the shoreline and subsequently enter the sea may be used to provide alerts and incident feedback to the appropriate authorities.

Beach State Analysis

The automated output from this phase will be a short time scale transition predictive model, presenting a picture of typical beach conditions and their changes over time. Relating these descriptions to the morphodynamic beach state model will further enhance the predictive

assessment tool “training”. An outcome of this work is a beach condition trend index which will take a set beach state as a starting point, then examine a range of simulation scenarios of beach and wind/wave/tide conditions thereby creating a matrix of predicted states and conditions. This index will have as a base reference, the CoastSAFE rating in use by SLSA, thereby creating a Dynamic Beach Risk rating – CoastSAFE Alive.

Dynamic Risk Assessment

Following the development of the individual components the output from each will be integrated to provide an accurate risk rating of a particular beach site. The combined information will result in a dynamic predictive model for assessing and reporting risk at beach sites.

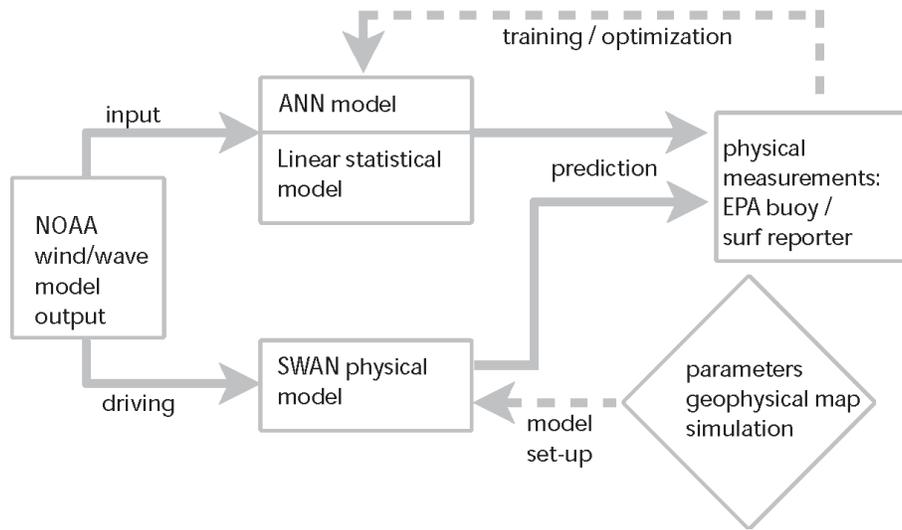


Figure 2. Integration of system components for risk assessment (Browne et. al., 2005)

Implementation of the system components

A separate group of tasks is concerned with data acquisition, automatic camera control, extensive data networks and storage and information dissemination. Coastalwatch has developed a Turn Key solution using source code provided directly from Sony Japan that enables the acquisition, processing and distribution of information directly from each camera site. The development of this system including scalability and quality control will form a key component of this phase of the research project.

To date, Coastalwatch has been able to develop specific software that allows for a camera to be individually controlled in order to collect information on a particular coastline. With further development of this software within this project scope the aim is to produce a CCTV data acquisition system that can be controlled internationally. In developing this software for the analysis of the Queensland coastline it will be possible to produce a program for use in any industry sector or any position globally. Remote control of a widely distributed camera network would become possible with minimal replication of hardware, software and personnel.

The CoastSAFE Alive project is working towards both the capacity for surveillance of all the cameras on one VPN network and, in particular, the intelligent acquisition of pre-processed data from cameras at widely distributed locations.

DISCUSSION OF PRELIMINARY RESULTS

Outcomes from the CoastSAFE Alive project will be reported in a series of Griffith Centre for Coastal management technical reports. The existing 40 camera sites within Queensland have been documented with the identification of an additional 10 sites to be installed in North Queensland. The extended camera network will cover virtually the full range of morphodynamic beach types and the proposed sites are primarily highly popular beaches which are patrolled by Surf Lifesaving Queensland (Williams, 2009). At the time of writing a literature review of existing beach hazard methodologies is underway and technical documentation regarding the integration of earlier research and automation techniques is being conducted.

TAKE HOME MESSAGE

The beauty and amenity of Australia's beaches are well recognised both in Australia and internationally. This project offers outcomes of national importance through the development of a beach risk assessment tool. There are direct economic benefits to Queensland through enhanced safety for beach users and the mitigation of instances of death by drowning which may have negative effects on tourism. The provision of enhanced monitoring facilities also informs coastal authorities about the health of the beach system and will assist in the longer term monitoring and planning for climate change impacts.

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REFERENCES

- Booij, N., Ris, R. C. & Holthuijsen, L. H. (1999), 'A third-generation wave model for coastal regions. 1. model description and validation', *Journal of Geophysical Research* 104(C4), 7649–7666.
- Browne, M., Tomlinson, R., Castelle, B. & Strauss, D. (2005). 'Estimating Onshore break size from a global wind wave model using neural networks', *CRC 2005, Coastal Research Conference*, Gold Coast, Australia.
- Browne, M., Strauss, D., Tomlinson, R. & Blumenstein, M. (2006), 'Objective beach-state classification from optical sensing of cross-shore dissipation profiles', *IEEE Transactions On Geoscience And Remote Sensing* VOL. 44, NO. 11, 3418–3426.
- Browne, M., Strauss, D., Castelle, B., Blumenstein, M., Tomlinson, R. & Lane, C. (2006a), 'Empirical estimation of nearshore waves from a global deep-water wave model', *IEEE GEOSCIENCE AND REMOTE SENSING LETTERS* 3 (4), 462–466.

Strauss, D., Browne, M., Tomlinson, R. & Hughes, L. (2006), Numerical modelling and video analysis of intermediate beach state transitions, in 'Proceeding of the 7th International Conference on Hydroscience and Engineering, Philadelphia, USA.'

Tolman, H. L., 2008. A mosaic approach to wind wave modelling. *Ocean Modelling*. 25, 35-47.

Williams, P. (2009) Queensland Coastalwatch Camera Locations and Recommendations Report. Griffith Centre for Coastal Management Research Report No. 93.

Wright, L.D. & Short, A.D., (1984). Morphodynamic Variability of Surf Zones and Beaches: A Synthesis. *Marine Geology*, 56 93-118., 1984