

A new system for breakzone location and the measurement of breaking wave heights and periods.

C.Lane, Y.Gal, M.Browne, A.Short, D.Strauss, C.Tan, K.Jackson, R. Tomlinson & M.Blumenstein
CoastalCOMS & Griffith University, Gold Coast

Abstract

This poster presents a new system for measuring breakzone locations, breaking wave height and wave periods across the surfzone from a digital video sequence. The system (Wave Pack) aims to provide real-time measurement of breaking and re-breaking wave heights and wave periods using low mounted video camera installations. Following on site data collection and analysis it was found that the Wave Pack system provides a low cost, robust, reliable and accurate system for measuring continuous wave height and period from a low elevation video camera aimed at the target beach under a wide range of wave conditions. These tests have verified the accuracy of Wave Pack in comparison to existing systems.

Introduction

This poster presents a new system for measuring breakzone locations, breaking wave height and wave periods across the surfzone from a digital video sequence. The aim of the system, called Wave Pack is to detect the breaking wave zone and measure breaking and re-breaking wave heights and incident through infragravity wave periods, based on digital video data that is streaming from a low altitude camera, located on the investigated beach. The system circumvents the need for expensive equipment, labour intensive and complicated installation presently used in hardwired surf zone sensors and inshore waverider buoys. It is a reliable system that can supply accurate results even in extreme weather and sea conditions.



The CoastalCOMS camera installed at a Penscola Beach Florida

Methodology

General System Structure:

The Wave Pack system consists of the following main components (Figure 1): (i) digital video camera, located and fixed 10 metres above sea level at the target site beach; (ii) video pre-processing unit that converts the streaming video into aggregated 'timestack' images (Browne et al. 2005); (iii) analysis unit that processes the extracted timestack and produces measurements of break zone location, wave heights and periods; and (iv) output unit that displays the analysis results to the user.

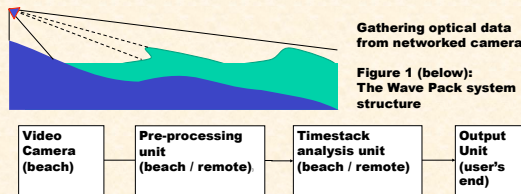


Figure 1 (below): The Wave Pack system structure

The camera is located and fixed on the investigated beach at an altitude of at least 7 metres above mean sea level, while the output unit is located at the user's end. The pre-processing and analysis units can be located either with the camera or remotely. Locating one or both unit on the camera site will dramatically reduce network communication and will prevent communication bottlenecks. Also, locating both units remotely will increase resolution and sampling rate of the timestack, also allowing remote processing of multi camera input and thus reduce the costs of buying a processing unit for each camera.

Methodology of data analysis:

Data analysis is performed on the timestack image (Figure 2) and consists of the following stages: (i) convert the timestack image from RGB colour to gray scale; (ii) normalise illumination along the temporal axis; (iii) detect main break zones; and (iv) calculate wave height and wave period for each breakzone detected.

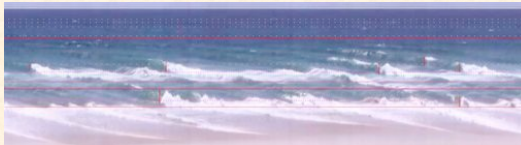


Figure 2: Section of timestack image with breakzones detected, swash zone (green line), outer break point (purple line) and measured breaking wave heights (vertical red segments). The horizontal dotted white lines represent different distances while the solid white line represents the calculated horizon.

System Validation:

In order to evaluate the reliability of the system, a validation study was performed using data from 39 daily video sequences taken from the double-barred beach of Narrowneck, Gold Coast, Australia. A total of 1466 waves were detected with only 76 detections discarded due to interference. Interference primarily resulted from human activities obstructing the image. The results of the Wave Pack were compared to several independent sources of near-shore wave height and period. These included output from Wavewatch III (Tolman 1997, 1999a, 2009), a waverider buoy located 1.2 km directly offshore, the empirically derived formula of Komar & Gaughan (1973), output from a SWAN (Booij et al. 1993, Holthuisen et al. 1993) model of wave propagation from offshore to the surf zone and the observations of a professional surf reporter. An additional manual verification of the accuracy of the pixel representation of breaking wave height was performed by visual inspection of each detected breaking wave in each timestack.

Results

The manual counts of pixels and the automated method corresponding to breaking wave height had a correlation of 0.6 and a mean absolute error of 5.1 pixels. The standard deviation of the manual counts of wave height in pixels was 6.05 pixels and the automated method was 6.64 pixels. The number of vertical pixels representing breaking wave height was converted to actual wave height by rectification of the visual field with the image co-ordinates. The results of the video derived and independent measures of wave height are presented in Table 1.

	Max Manual	WW3 Hs Anl	Buoy Hs	Buoy Hmax	SWAN Hs max	KG73 WW3	KG73 Buoy	SR
Wave-Pack Max	.86	.85	.82	.80	.66	.68	.83	.77
Max Manual		.86	.88	.85	.70	.69	.89	.78
WW3 Hs Anl			.98	.94	.70	.69	.95	.83
Buoy Hs				.96	.77	.64	.99	.80
Buoy Hmax					.71	.63	.97	.76
SWAN Hs max						.72	.78	.61
KG73 WW3							.96	.82
KG73 Buoy								.82
MAE meters (Wave-Pack max)	.33	.79	.77	.89	.42	.45	.85	1.01
MAE meters (Manual max)		.88	.85	.84	.49	.50	.71	1.12

Table 1: Correlation matrix of video derived and independent sources of wave height data.

The processed maximum wave period data was compared against two independent measures of peak wave period: the Gold Coast wave buoy (moored at a depth of 16m, approximately 1.2km offshore) and the closest available WW3 grid point. The manual estimates of wave period were derived by counting the number of visible waves at the identified break line in each time stack image and dividing the length of video (in seconds) by the wave count. Essentially this results in a mean period. Nevertheless, a reasonable correlation would be expected with peak period measurements but that is not the case. It appears that this highly subjective method for manually estimating the wave count is a poor choice for validation. The processed values for maximum wave period obtained from the time stacks result in correlations with the both the waverider buoy and Wavewatch III peak periods of 0.53 and 0.65 respectively. The highest correlation (with WW3) is equivalent to the wave buoy correlation with WW3. Mean absolute errors of processed wave period with the buoy and WW3 are less than 1.3 seconds whereas the mean absolute error of the manual calculation of wave period is greater than 3 seconds in all cases.

Conclusion

A new method of obtaining accurate measurements of breakzone wave height and period from video imagery is presented. These were tested using a set of 39 timestacks covering a range of wave heights and periods. The relatively low percentage of rejected wave counts supports the flexibility of the wave height processing algorithm to perform in the highly variable wave conditions experienced at a field site. The processed wave heights correlated highly with the independent sources of wave height available. The empirical formulation of Komar & Gaughan (1973) was tested using Wavewatch III and waverider buoy data as input. While the calculated values also compared favourably with the processed values there is expected to be several restrictions on the application of the empirical model in more complex bathymetries. The Wave Pack system provides a low cost, robust, reliable and accurate system for measuring continuous wave height and period from a low elevation video camera aimed at the target beach under a wide range of wave conditions. Field tests have verified the accuracy of Wave Pack in comparison to existing systems.

REFERENCES

- [1] M. Browne, M. Blumenstein, R. Tomlinson, & C. Lane, "An intelligent system for remote monitoring and prediction of beach conditions", *Proceedings of the International Conference on Artificial Intelligence and Applications*, Innsbruck, pp. 533-537, 2005.
- [2] N. Booij, R.C. Ris and L.H. Holthuisen, "A third-generation wave model for coastal regions", *Journal Geophysical Research C4*, Part I, Model description and validation, vol. 104, pp. 7649-7666, 1999.
- [3] L.H. Holthuisen, N. Booij and R.C. Ris, "A spectral wave model for the coastal zone", *Proceedings of 2nd International Symposium on Ocean Wave Measurement and Analysis*, New Orleans, USA, pp. 630-641, 1993.
- [4] P.D. Komar and M.K. Gaughan, "Airy Wave Theory and Breaker Height Prediction", *Proceedings of the 13th Coastal Engineering Conference*, American Society of Civil Engineers, New York, pp. 405-418, 1973.
- [5] H.L. Tolman, "User manual and system documentation of WAVEWATCH-III version 3.14", NOAA / NWS / NCEP / MMAB Technical Note 276, pp. 194, 2009.
- [6] H.L. Tolman, "User manual and system documentation of WAVEWATCH-III version 1.18", NOAA / NWS / NCEP / OMB Technical Note 166, pp. 110, 1999a.
- [7] H.L. Tolman, "User manual and system documentation of WAVEWATCH-III version 1.15", NOAA / NWS / NCEP / OMB Technical Note 151, pp. 97, 1997.

CoastalCOMS

