Tuning a heaving wave energy converter

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The challenge

- To improve power capture performance
  by adapting to changing sea states

- Linear control theory does not cover the range of operating conditions

The objectives

- To develop adaptive control systems for generic devices
- To investigate their performance over changing sea states

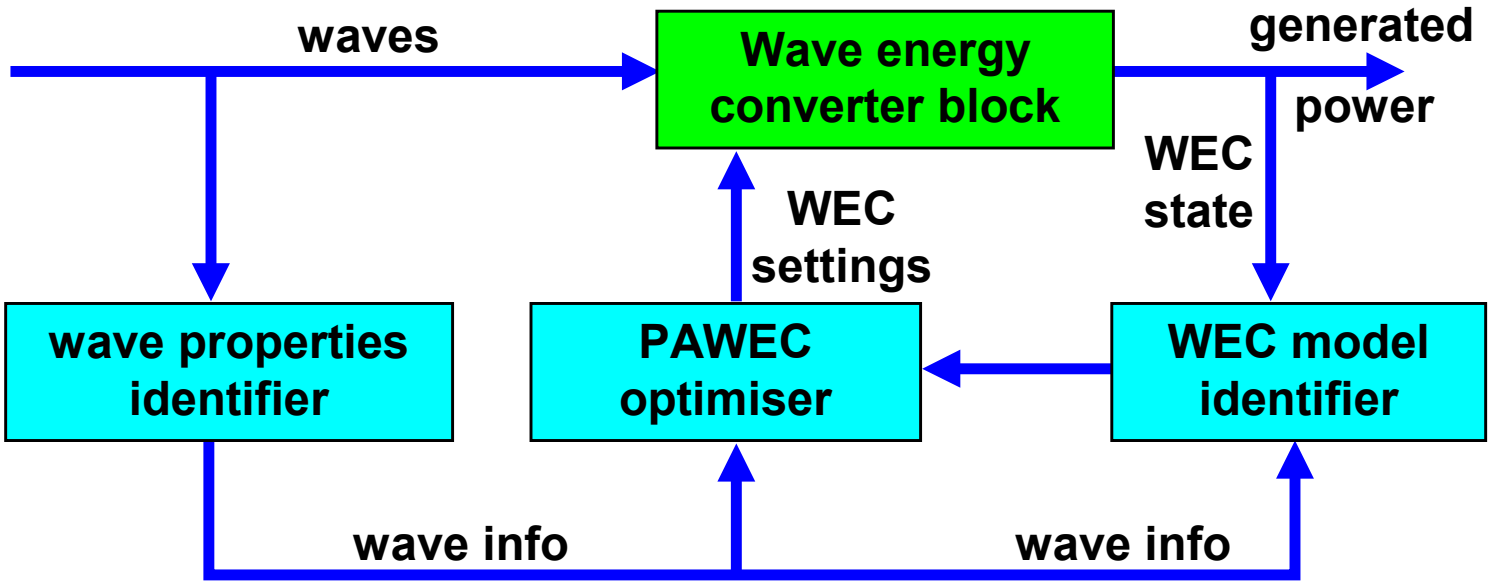
Research in 3rd year

- FD studies for regular sea states have been performed on
  - analysis of heave and surge models
  - magnitude of power capture
  - tuning basics

- TD model studied for
  - heaving device
  - transient power capture
  - response in regular and irregular sea states

Research output for 3rd year

Adaptive control technique outline



- Measure wave elevation
- Measure WEC state
- *Identify wave properties*
- *Identify WEC model parameters*
- *Calculate WEC settings*
- Adjust WEC settings

Control techniques

$P_{1,2}$: Passive

- Based on (ω_e and ω_p) of sea state

A_1: Local (group) frequency

- DFT over short interval, e.g. 100 seconds

A_2: Incident wave period estimation

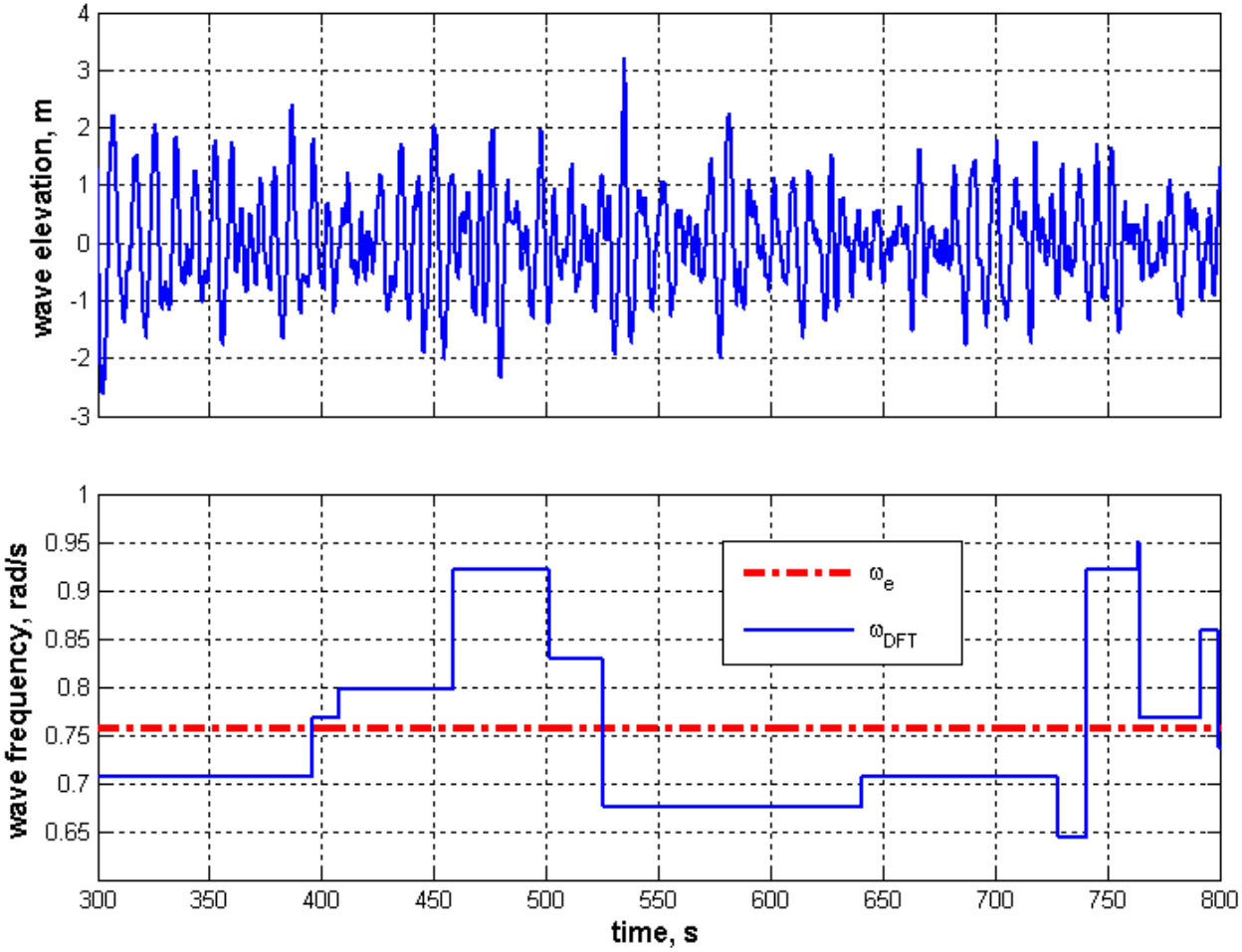
- No future wave knowledge required

A_3: Period matching

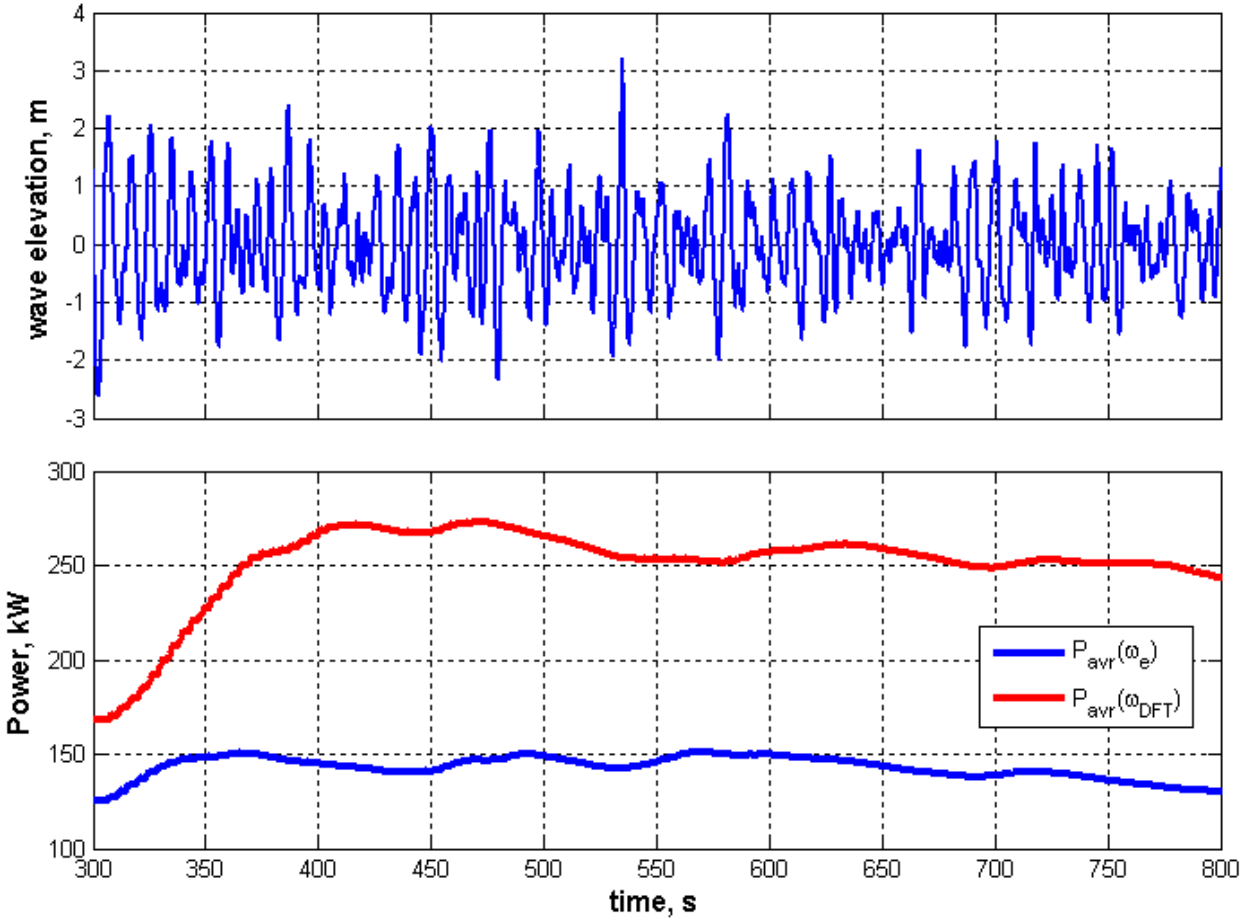
- No device or future wave knowledge required

Paper ($P_{1,2}$ A_1) accepted by IMechE JEME in March 2006.
Paper ($P_{1,2}$ A_1,A_2,A_3) submitted to IMechE JPE in April 2006.

Estimation of wave frequency



Power plots


wave elevation, m
4
3
2
1
0
-1
-2
-3
Power, kW
300
250
200
150
100
300
350
400
450
500
550
600
650
700
750
800
time, s
$P_{avr}(\omega_e)$
$P_{avr}(\omega_{DFT})$

Performance comparison

$$P_2(\omega_p) = 1.18 \times P_1(\omega_e)$$

$$A_1(\omega_{DFT}) = 2.12 \times P_1(\omega_e)$$

$$A_2(T_\zeta) = 2 \times P_1(\omega_e)$$

$$A_3(T_{\zeta,V}) = 1.49 \times P_1(\omega_e)$$

Based on mean power capture in 64 irregular wave-fields defined by

JONSWAP spectrum with differing bandwidth.

The Results

- Three novel adaptive control techniques developed and modelled – not reported anywhere as of 12 months ago.

- Power capture performance compared in irregular seas
  - 100% Increase without future wave knowledge (A2)
  - 50% Increase without system or future wave knowledge (A3)

Future direction for work

- validation by experimental work
  - Adding correction factors in
    - Model
    - Control technique