



**Best Poster Award**



**Motivation**  
**Relevance, Innovation**  
**Simplicity and Applicability**



## Introduction

This research demonstrates a novel, non-invasive approach to measuring groundwater level using community handpumps. Water level beneath a handpump can be estimated using acceleration data generated by a low-cost accelerometer embedded in the pump handle.

At scale this would enable the handpump infrastructure across Sub-Saharan Africa to be transformed into a large-scale, distributed shallow groundwater monitoring network.

Proof-of-concept work was undertaken in the first half of 2014 and continues under the ESRC/NERC/DfID UPGro programme.

## Smart Handpumps

This work is part of Oxford University's Smart Handpumps project. Smart Handpumps proof-of-concept was demonstrated in August 2011. The first operational Smart Handpumps were installed in Kenya on 2012 as part of an operational trial linked to a rapid maintenance service.

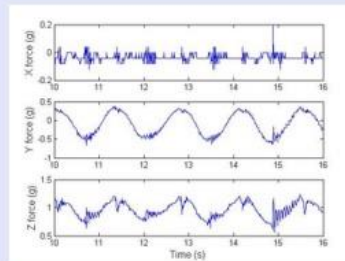


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## Methodology

Handpump dynamics are a function of a number of different factors, e.g. pump type, pump condition, user's pumping technique, height and strength. Depth to water changes pump dynamics as the weight of pump rods and weight of water in the rising main both increase with depth.

Using data generated by operational handpumps in Kenya and a test-bed handpump in Oxford, we characterised pump dynamics from acceleration data generated by a low-cost accelerometer embedded in the pump handle.



3-axis acceleration of Afridev pump handle.

We gathered accelerometry data from a test pump over a period of varying groundwater level.

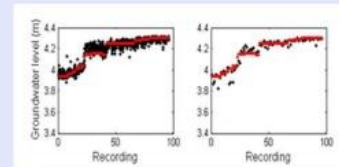
We characterised features of the accelerometer signal from different pump-user-time combinations using both the shape and noise profile of each period of pumping.

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## Results

We estimated the effects of water-level change by learning the relationship between measured depth and the features that were extracted from the waveforms, using a support-vector regressor (SVR), a machine learning method for learning the mappings between high-dimensional sets of features and an output measure.

To ensure rigour, we used 75% of the data gathered for training the model, holding back the remaining 25% for testing and validation. The two charts below show the results for the testing data set against measured depth.



Measured depth [red] vs. predicted depth [black] by spline [left] and by recording [right].

These data clearly show that the model tracks measured depth for individual splines, with accuracy increasing when predictions are averaged over an entire recording (around 20 litres of pumping).

It should be noted that in an operational setting, there will be significantly more periods of pumping than were used in our experimental work, thereby increasing accuracy.

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## Implications

The policy implication of this work is that the thousands of community handpumps across sub-Saharan Africa and south Asia have the potential to act as a distributed groundwater monitoring network, often in areas where groundwater data is sparse.

The need for these data are becoming even more important in the face of climate change, as groundwater resources may have a key role to play as a buffer against changes in precipitation and surface water flows.

As well as environmental monitoring, the same data stream can provide information on handpump usage and functionality, providing greater understanding of rural water use and enabling improved rural water service.

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## Partner and Funders

This work was funded by Oxford University's John Fell fund. Work is continuing under the ESRC, NERC and DfID funded UPGro programme.

In Kenya we work with the University of Nairobi, Jomo Kenyatta University of Agriculture and Technology and Rural Focus Ltd. The work is supported by industry partners, Base Titanium Ltd. and KISCOL.

We work with the Government of Kenya in the form of the Water Resources Management Authority (WRMA), Water Services Regulatory Board (WASREB) and the Counties of Kwale and Kitui.

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... and the winner is  
Mr Patrick Thomson, University of Oxford, UK