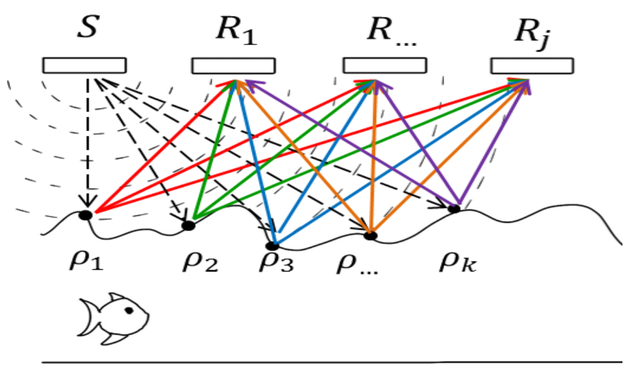
The University Of Sheffield.
Department Of Mechanical Engineering.
Dynamics Research Group drg.ac.uk
Giulio Dolcetti[a], Anton Krynkin
[a]: g.dolcetti@sheffield.ac.uk

Optimised array of ultrasonic sensors RECONSTRUCTION of rough surface

- Floods damages cause £1.1b annual cost in England.[1]
- Existing technologies to monitor flow - invasive and expensive.
- **We propose acoustic remote monitoring techniques.**

- Fluid dynamic results[2]: **spatial and temporal scales** of the free water surface
- Fluid dynamic results[2]: directly relate to the **main hydraulic quantities of shallow flow**.
- Acoustic results[3,4]: **improvement of non-contact flow velocity** measurement based on ultrasound Doppler.
- Acoustic results[5]: **reconstruction of the free surface** shape and dynamics based on holographic principles.

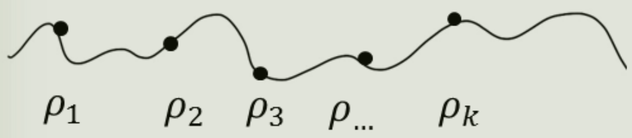
- **Principle of operation of the acoustic imaging technique applied to a rough surface profile:**



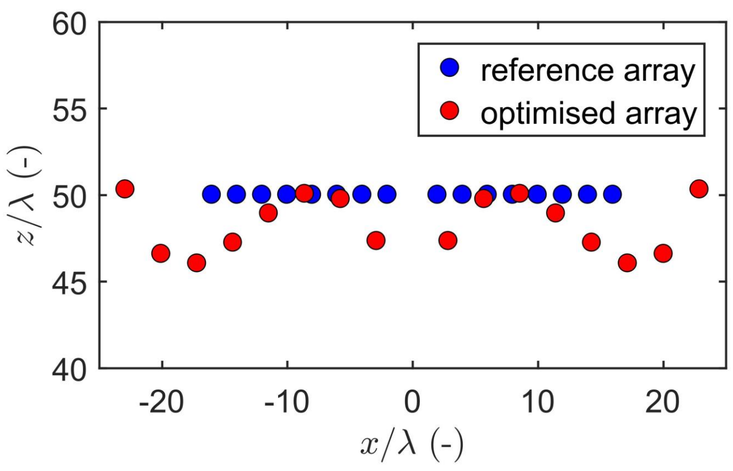
The problem has a matrix form:
$P_{N_R \times 1} = H_{N_R \times N_k} E_{N_k \times 1}$.

Reconstructed surface elevation $\eta(\rho_k)$:

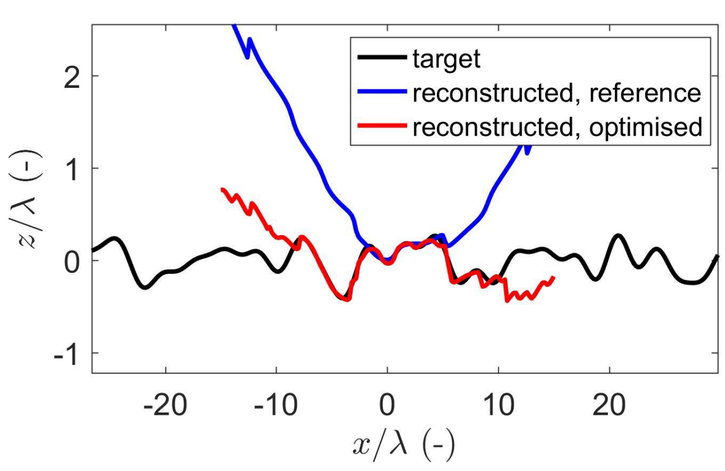
$$\eta(\rho_k) = -\frac{\Im[\ln e_k]}{q_z}$$

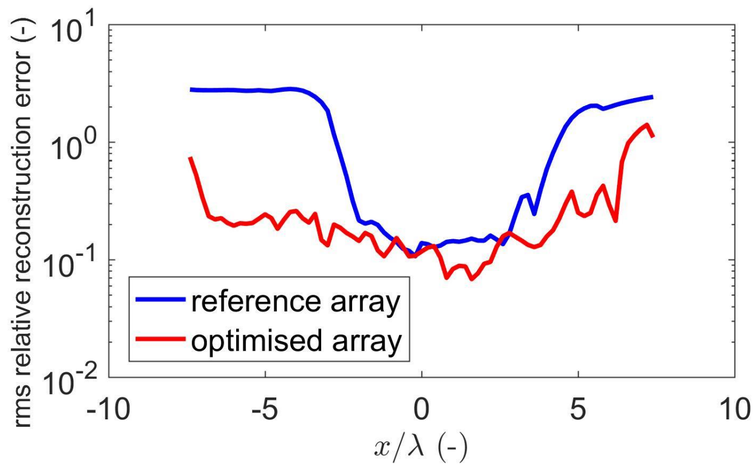


- **Optimization based on Self-Adaptive Differential Evolution (SADE) Algorithm[6]**



Linear array converted into the optimised shape

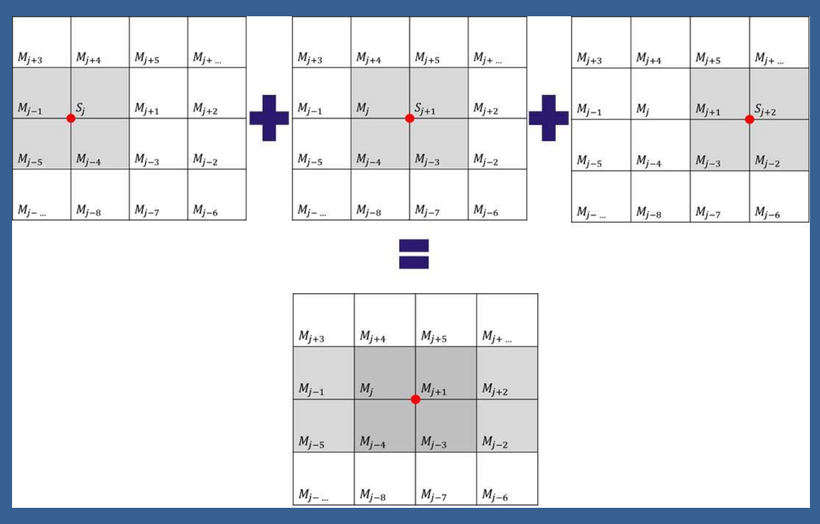




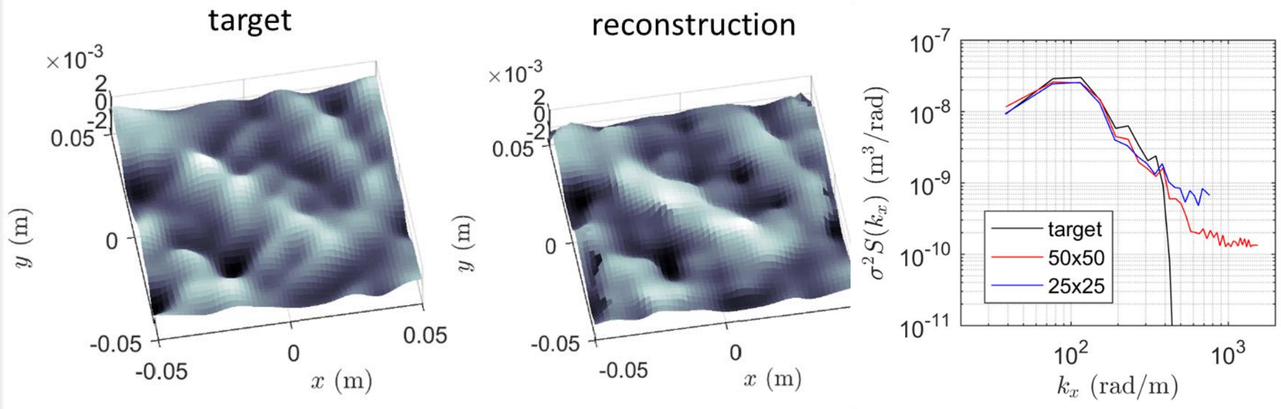
Optimised array allows reconstructing surface with improved accuracy over longer surface interval compared to the original (linear) array

- **In 3D optimization is also used to reduce number of transducers**

Distribution of transducers for 3D surface reconstruction



Three-dimensional surface:



Numerical simulation.
7x7 (49) sources and receivers. 50x50 (2500) reconstruction points.

Surface spatial spectrum.

[1]Priestely, House of Commons Library Briefing Paper CBP07514 (2016); [2]Dolcetti G., et al., Physics of Fluids 28, 105105 (2016); [3]Dolcetti, G. and Krynkin, A., The Journal of the Acoustical Society of America 142 (2017); [4]Dolcetti, G. et al., The Journal of the Acoustical Society of America 142 (2017); [5]Krynkin A., et al., Review of Scientific Instruments, 88(2017); [6]Qin, A.K. and Suganthan, P.N., IEEE Congress, Evolutionary Computation (2005).