University Defence Research Centre (UDRC)
In Signal Processing

Sponsored by the UK MOD

[O12] Real time Non-linear System Identification
Theme: Non-conventional Signals

PI: Alex Gong, University of Reading

Researchers: Xia Hong and Hao Chen

Status Quo

❑In many practical especially military applications, the underlying systems are often non-linear and highly non-stationary. Identification/modelling of such systems are thus very important and yet challenging.

❑The objective of the project is to investigate efficient approaches for real time identification in non-linear and non-stationary systems.

❑While there exist many on-line approaches, few can well track the non-stationary system in real time. Some drawbacks of existing approaches are

- The modelling structural is not optimized for the ever-changing systems.
- The model size is often too large, resulting in not only high complexity but also poor generality (tracking) performance in non-stationary scenarios.

Technical Work

❑Linear-in-the parameter models such as the radial base function (RBF) are of particular interests due to their simplicity and yet good matching for non-linear systems.

❑In the RBF network, the incoming data pass through a bunch of non-linear nodes, the node outputs are then weighted by node coefficients and finally summed up to give the model output. By updating the node coefficients, the RBF structure is widely used for on-line approaches.

❑In non-stationary systems, however, not only the model coefficients but also its structure should be updated. The structure of a RBF network consists of

- Model size: the number of the node
- The centres of each node
- The shape (the covariances) of each node.

❑The model size can be kept minimum if the model structure is optimized on-line.

❑Based on this observation, we propose a novel RBF with tunable structure.

The RBF network with tunable structure

❑The model size is fixed at a small number.

❑When the modelling performance decreases, the worst performing node is replaced by a new node.

❑The structure of the new node is optimized. Both particle-swarm-optimization and iterative optimization approaches are proposed.

❑**Novelty of the proposed approach**

- The proposed RBF structure has much more sparse model than existing approaches.
- While the structure optimization is usually a hard NP problem demanding high computation complexity, we propose fast and very efficient algorithms for the structure optimization.
- Outperform all existing on-line approaches in non-stationary environment.

Summary

❑We propose a novel RBF network for real time system which is fundamentally different from existing on-line approaches. The proposed approach can also be easily extended to other non-linear models.

❑By on-line updating both the structure and coefficients, the proposed RBF network can well track the non-stationary system with a very space model.

❑We propose fast and efficient algorithms for the structure optimization, a key part in the proposed approach. This ensures that proposed approach has small complexity and can be implemented in practical systems.

Potential military relevance & applications of results

❑The proposed approach has wide military applications because systems in military environment are often not-well structured and highly dynamic (non-stationary).

❑Just a few potential applications are listed as follows

- Trajectory tracking of the incoming flying objects (e.g. missiles).
- Active noise cancellation in highly noisy battle environment (e.g. tanks, air-fighters).

[dstl]

MINISTRY OF DEFENCE

EPSRC
Engineering and Physical Sciences Research Council

This work was supported by the Engineering and Physical Sciences Research Council (EPSRC) and the MOD University Defence Research Centre on Signal Processing (UDRC).