University Defence Research Centre (UDRC)
In Signal Processing

Sponsored by the UK MOD

[O21] Bayesian Compressed Sensing, Tracking and Classification
Theme: Detection, Localisation & Tracking Theme

PIs: Wei Dai, Cong Ling, Imperial College London
Researchers: Jason Filos, Imperial College London

Project Objectives:

- Modern defence applications (e.g. wide-band spectrum surveillance, real-time object tracking, reliable entity/activity identification) call for efficient and cheap mechanisms to **acquire** and **analyze** huge amounts of digital data.
- Traditional paradigm often results in bulky system with low efficiency, i.e. not efficiently using sensing and processing resources.
- **Key Novelty**: Hierarchical Bayesian infrastructure addressing **sensing**, **tracking** & **classification** simultaneously.

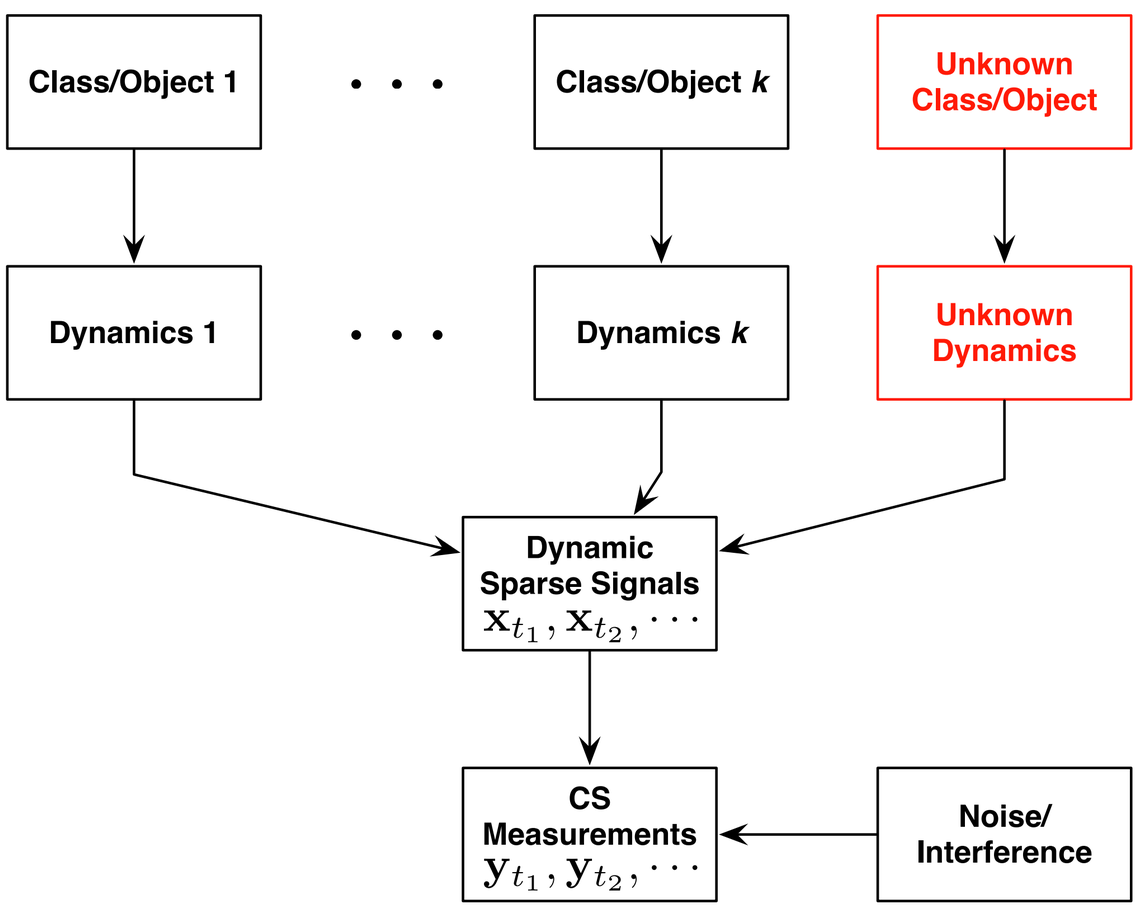


Figure 1: Proposed hierarchical Bayesian infrastructure jointly addressing **sensing**, **detection**, **classification** and **tracking**.

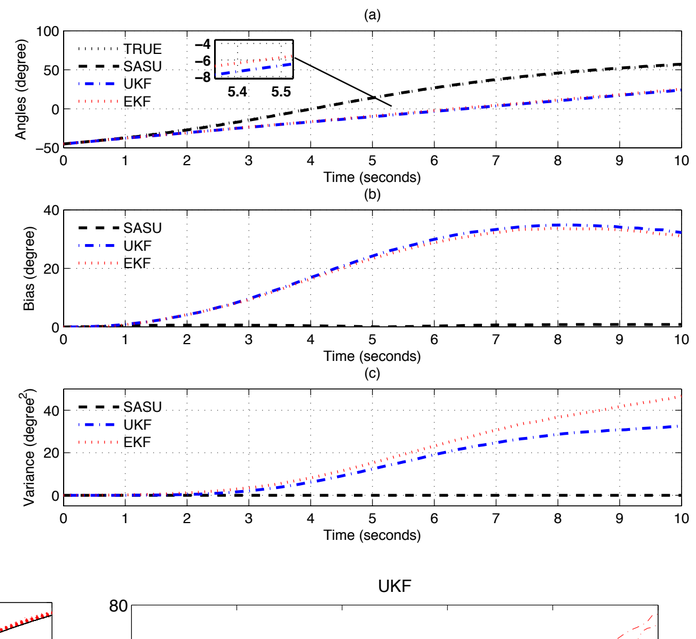
Goals:

- Extended frequency coverage for spectrum surveillance of radar and communication signals
- Efficient tracking algorithms for dynamic signals and moving objects
- The ability to identify known signals/objects/activities and detect unknown ones (anomalies)
- Provide human-friendly confidence information for sensing, tracking, and identification

Research Approach:

- **Task 1**: Tracking sparse signals with Bayesian CS.
  - Key issue is statistical modeling of the dynamics.
  - **i**) Should address the randomness of signals; **ii**) take correlations over time into consideration; **iii**) render efficient strategies from **both** CS techniques and Bayesian statistics
  - Approach based on the relevance vector machine (RVM) from machine learning literature:
    - RVM supports automatic relevance determination (hyper-parameters automatically determined from interference network)
    - RVM give full posterior distribution and not only point estimate
- **Task 2**: Bayesian CS with Classification.
  - Both number of classes and corresponding statistical models can be learned online form observed data.
  - Classification performed as part of data analysis.
  - Confidence information allows for **adaptive** resource allocation.

Figure 2: Single target tracking: Bias (b) and variance (c) comparison.



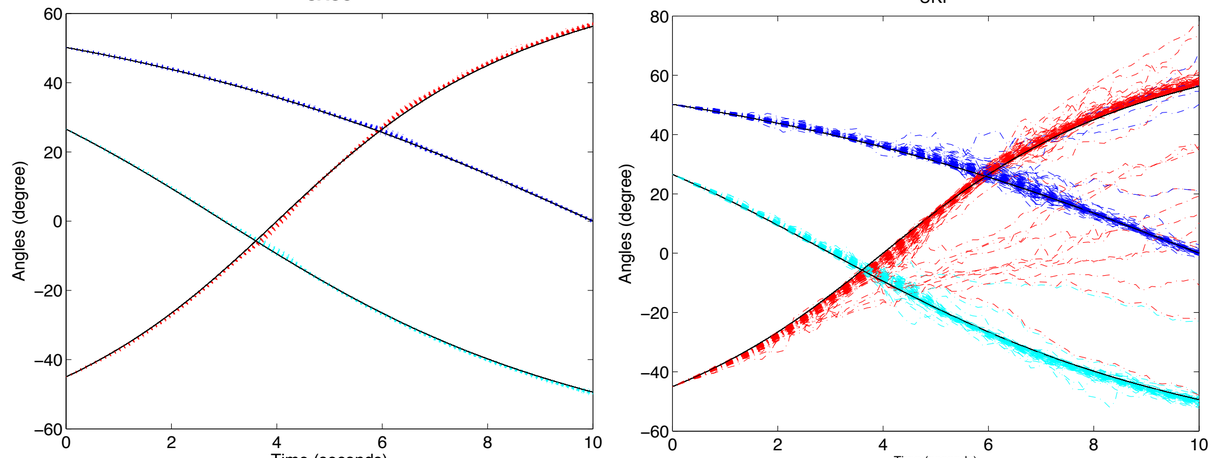


Figure 3: Three targets tracking: Robustness comparison SASU (left) and UKF (right).

MINISTRY OF DEFENCE

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).