Parametric Advanced Reconfigurable Sensor Emulation & Characterisation (PARSEC) Framework

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PARSEC is designed to allow intra-platform and inter-platform multi-sensor fusion to be modelled and explored parametrically and can model multiple sensors on multiple platforms simultaneously.

The target and modelling processes are designed specifically so that the different sensors see the same dynamic target behaviours coherently in time-and-space. That is, if a target manoeuvres, then an L-band ground based radar would see appropriate radar signals from the manoeuvre at the same time as an X-band missile seeker and IIR sensor would see their equivalent responses. Therefore cross-sensor data fusion can be conducted properly.

Currently PARSEC includes models for multiple forms of radars operating in multiple bands, for example ground based long-range surveillance radars, medium range fire control radars, and missile seeker radars. PARSEC has models of mechanically scanned and E-scan antenna systems, and WHR also have all the elements of a full multi-function E-scan radar that are gradually being integrated into PARSEC; that is the multi-function radar will include all the time scheduling and radar resource management processes that decide where to look next to allow surveillance and tracking tasks to be interleaved, with the scheduling reacting dynamically to the target behaviour etc. The radar signal modelling is conducted at pulse-level on a sample-by-sample basis, with the entities in the scene all moving between pulses (or moving between samples for FMCW radar), allowing coherent modelling of the returns and therefore accurate Doppler behaviours to be captured. With the pulse level modelling, the signal processing stages of the radar have to be representative of the actual algorithms, rather than being a model of the signal processing behaviour. For example, all of the radars have the facility to use a wide range of pulse compression and range-Doppler signal processing algorithms that are available within the PARSEC tool-set. WHR also have design tools to allow us to generate appropriate waveforms, such as MPRF waveform sets that are fully decodable, and also tools for configuring beam packing for E-scan surveillance, and beam-spoiling calculations. For the E-scan systems, PARSEC also has a range of adaptive beamforming algorithms implemented, such as STAP for airborne platforms.

WHR have a range of radar targets modelled, such as 'generic aircraft' (both conventional and low-observable airframes), ship and tank models, many of which can cover the 1-3GHz long-range surveillance bands, the 6-18GHz fire control and some missile bands, and also models fitted for 35GHz operation. PARSEC can also model targets with articulated structures, such as in its helicopter model where each rotor blade can articulate independently as they rotate. The rotary wing models can also generate corresponding rotor wash velocity fields so that appropriate motion of smoke or chaff in the rotor wash can be modelled. PARSEC can use simple radar models, such as statistical methods, where rapid low fidelity studies are needed, but normally high-fidelity scatterer models are used. The scatterer models are usually arranged in a tree structure to provide accurate range profile data over a full 4π Steradians, with options to use additional lookup tables to further refine the RCS fidelity. Radar scintillation and glint effects are faithfully captured by the scatterer RCS models as the target (and radar vehicle) manoeuvre, capturing the effects of antenna orientation and target polarisation changes too if needed.

PARSEC has a set of decoy and countermeasure models that can be used, including both models of physical decoys and electronic countermeasures, and can model the effects of multiple simultaneous countermeasures. Knowledge-based systems may be incorporated with the countermeasures in order to model coordinated effects. There are extensive surface and volume clutter models within PARSEC, including the ability to integrate terrain maps, and also to update the clutter behaviour as missiles change their position and seeker look angles, so look-down missile engagements can be considered properly, even for very high-speed missiles where the clutter spread in Doppler is very wide. PARSEC has two different forms of clutter modelling available; a fast model that is useful for radars that are mostly concerned with classical radar detection processing, and also a more detailed model that is fully spatio-temporally coherent that allows adaptive methods such as STAP to be used and processed properly.

PARSEC includes an Imaging Infra-Red sensor model that can render images of multiple targets in a frame, with the dynamic motion fully spatio-temporally coherent with the motion observed by the radar sensors, and any other IIR sensors in the scene. The IIR rendering is currently designed for 'look up' scenarios as only very limited background scene rendering implemented at present. Extending the EO background modelling is planned for the future, and models of the ground scene etc. could be made properly spatio-temporally coherent with the radar data too. Algorithms for detecting, segmenting and tracking multiple targets within the IIR images are available within PARSEC and multiple different IIR sensors can be used simultaneously within a scene.

For the objects in the scene, PARSEC can either have objects moving through defined paths, such as aircraft targets, where the body calculations for banking to turn etc. are conducted automatically for the manoeuvre, or objects can move based on their aerodynamic and control behaviour, such as dropped decoys decelerating under aerodynamic drag, or missiles manoeuvring under the seeker-derived commands. The only limit to the number of entities in the scene is how much processing and memory you have on a machine.

The data fusion suite within PARSEC consists of flexible multi-target tracker frameworks that can incorporate a range of different estimators, such as Kalman filters, Extended Kalman Filters, Unscented Kalman Filters or Particle Filters etc. An advanced Knowledge Based System (KBS) is also available that has an internal multi-threading state-machine capability, as well as rule-based activities. The KBS can be used to 'contain' many objects; for example it can act as a wrapper around an entire missile sensor, allowing waveform switching, and operations such as using a radar at long range, and then switching in an additional IIR sensor at shorter ranges to be conducted, with all the rules being accessible for exploration as part of a parametric study. The KBS can also be used within the individual track files of the multi-target tracker so that the track estimator type or configuration for each track could be changed dynamically based on any target identification information that may be available for example.

PARSEC is object-oriented and written as a toolbox of Matlab classes that are coordinated through an external XML file which provides the definitions of the sensors, targets and scenario. Definitions within the XML file allow parametric variation and Monte-Carlo repeat trials to be managed easily, with the trials of a batch process being run in parallel to reduce overall simulation time. PARSEC uses a dynamic time step system with no underlying fixed simulation clock to allow sensors to be modelled with unsynchronised clock systems, allowing evaluation of data fusion systems where the sensors have different sample rates and latency. An animation manager is provided that allows multiple videos to be created from figures windows during the simulation, but with synchronised frame capture to allow the videos to be played back together. A data log manager is used to both capture simulation data to file during a run, and also later post-process the log files.