DUST

Distributed a**U**tonomous **S**pectrum managemen**T**

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Building the Australian cyber and spectrum security future

There is an ever-increasing need for and reliance on electromagnetic spectrum (spectrum) to operate effectively in military and commercial settings. Without sufficient spectrum access, Defence's ability to sense and coordinate action is compromised; additionally, fixed spectrum assignments provide initiative to an adversary.

Spectrum licensing at the national level is inflexible, manual, outdated, slow, and within the Defence allocation. Spectrum access is currently assigned through a manual process with few decision aids. The electromagnetic environment is complex, contested, congested and the dimensionality of spectrum is often too complex for timely human decision making. Current systems simply lack the necessary efficiency and resilience; they rapidly break down in an adversarial context and wide area or space applications.

Modern technologies offer the potential to use otherwise underutilised spectrum, and a robust, dynamic Spectrum Management system is required to fully realise this potential. The DUST project does just that through improved spectrum utilisation, agility and efficiency using high-fidelity, dynamic allocation of spectrum.

The DUST approach uses specialised Machine Learning (ML) techniques to forecast and anticipate spectrum. Artificial Intelligence (AI) planning using generated forecasts and live sensing enables distributed dynamic spectrum assignment in near real-time. Spectrum sharing techniques enable rapid adaptation to ever-changing situations and maximise/increase gains in spectrum efficiency. Consunet has been investing in and leading the development of DUST since 2019.

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Data

Data formatting can be manipulated to allow transforms and optimisation for use in the various ML and AI technologies used and developed by the DUST team. Synthetic data is essential for the training of ML models, creation of a ground-truth for AI based planning and the ability to generate insights and improvements. In addition to utilisation for ML and AI, the data itself has utility as a product to create realistic background spectrum for other systems such as simulation, emulation, or testing.

Spectrum Management / Artificial Intelligence

Application of AI Planning and Scheduling techniques to the problem domain of Spectrum Management creates spectrum efficiency opportunities. The clever exploitation of Spectrum Forecasting makes use of previously unused spectrum, minimises spectrum damage and coordinates the access/usage across large groups of users. As the spectrum environment becomes more complex, spectrum planning is best conducted through computational algorithms to avoid human error and poor timeliness, as machines can continuously generate viable spectrum plans. Combining this planning ability with anomaly detection enables a highly adaptive, continuous near real time Spectrum Management capability.

Spectrum Simulator

The Spectrum Simulator is known as Ark. The Ark software simulates electromagnetic spectrum usage for a “city-scale” number of users. The simulation models power spectrum and abstract detailed physics models to an appropriate level. Communication systems (e.g. Wi-Fi) have models within the simulation that generate events of spectrum usage. ‘Agents’ are used to represent people (and autonomous systems) with several devices in the simulation that have patterns of movement across time (e.g. Work/Home patterns). Ark is also capable of simulating the effects of the environment (e.g. buildings or trees) on spectrum efficiency using propagation loss models.

Spectrum Forecasting / Machine Learning

Spectrum Forecasting is the application of ML models using past spectrum utilisation data. Spectrum Forecasting has been divided into the following three distinct problems:

1. Temporal forecasting of spectrum occupancy for individual receivers at a specific location using historical spectrum data from the same location.
2. Spatial interpolation of spectrum occupancy at arbitrary points in space, at a fixed point in time.
3. Spatiotemporal forecasting performs simultaneous temporal and spatial predictions.

Additionally, with the ability to spectrum forecast via Machine Learning, extensions to perform anomaly detection can allow for identification of unusual activity.

Spectrum Sharing

Trusted negotiation techniques unlock further dynamic adaptability and spectrum efficiency potential by reassigning newly available ‘sensed’ spectrum and underutilised planned reservations to those that need it. This technology can enable collaborative ‘coalition’ Spectrum Sharing.

By addressing Spectrum Management problems with the technology of today, DUST users will gain resilient dynamic spectral planning and manoeuvre capability essential for the conduct of operations in both Defence and commercial applications. Unexpected and non-cooperative actors can be detected and either outmanoeuvred or rendered ineffective via the cooperative processes provided by DUST for Defence applications. Commercially, users will gain greater access to the spectrum for the benefit of suppliers and users.