Thesis abstracts

This section presents the abstract of most recent Master or PhD thesis related to aerospace technology and management

A Comprehensive Investigation of Retrodirective Cross-Eye Jamming
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Thesis submitted for PhD degree in Electronic Engineering at the University of Pretoria, Pretoria, South Africa, in 2010.

Advisors: Professors J. Wimpie Odendaal and Johan Joubert

Keywords: Electronic countermeasures, Jamming, Monopulse radar, Tracking radar, Electronic warfare.

Abstract: Cross-eye jamming is an electronic attack technique that induces an angular error in the radar being jammed. The main benefit of cross-eye jamming is that it is effective against monopulse tracking radars, which are largely immune to other forms of jamming. The objective of this research was to gain a complete understanding of cross-eye jamming so that systems that might be developed in future can be properly specified. The main contribution of this work is a comprehensive mathematical and experimental study of retrodirective cross-eye jamming. The mathematical analysis considers all aspects of an isolated, single-loop, retrodirective cross-eye jamming engagement, thereby avoiding the approximations inherent in other cross-eye jamming analyses. Laboratory experiments that accurately represent reality, by using the radar for both transmission and reception, and simulating a true retrodirective cross-eye jammer, were performed to validate the theoretical analysis. Lastly, the relationship between the angular error induced in the radar being jammed and the matching required from a cross-eye jammer system was explored. The most important conclusion of this work is that the traditional analyses of cross-eye jamming are inaccurate for the conditions under which cross-eye jammers operate. These inaccuracies mean that the traditional analyses are overly conservative, particularly at short ranges and for high cross-eye gains, suggesting that practical cross-eye jammers can be realized more easily than is generally believed.

Ant Colony Optimization Applied to Laminated Composite Materials
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Thesis submitted for Masters in Mechanical and Materials Engineering at Universidade Tecnológica Federal do Paraná (UTFPR), Curitiba, Paraná, Brazil, in 2010.

Advisor: PhD Marco Antonio Luersen

Keywords: Ant colony optimization, Meta-heuristic, Laminated composite materials.

Abstract: The ant colony algorithm is a heuristic that was formulated in the 1990s by Marco Dorigo. The idea was inspired by the behavior of real ants, related to their ability to find the shortest path between the nest and the food. This search was running by exploiting the pheromone trails, a chemical substance deposited by the ants during their journeys. Due to this cooperative behavior and effective search, the ants build better alternatives on the path to find food. This behavior was then simulated in optimization algorithms, called ant colony optimization. Thus, this dissertation aimed at studying and applying the ant colony method to the optimization of laminated composite materials. This kind of material is made by stacking plies, in which each ply is composed by a matrix, usually polymeric, reinforced by fibers. Usually, its optimization is related to the best settings of the orientation angles of the plies, and consequently the fibers. The variant ant colony system is implemented and applied to laminated composite plate issues, such as the maximization of the strength, the minimization of the cost, and the maximization of the fundamental frequency. This last issue was also solved using an interface with the finite element program ABAQUS, allowing the optimization of problems without an analytical solution for the structural response. The numerical tests carried out indicate that the method is competitive compared to other techniques found in the literature for the optimization of composite laminates materials.
Classifying Low Probability of Intercept Radar Using Fuzzy ARTMAP

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Keywords: Classification, Detection, Electronic warfare, Electronic support, Estimation, Fuzzy ARTMAP, Intercept receiver, Low probability of intercept, Parameters, Performance, Radar.

Abstract: Electronic support operations concern themselves with the ability to search for, intercept, track, and classify threat emitters. Modern radar systems in turn aim at operating undetected by intercept receivers. These radar systems maintain low probability of intercept by using low power emissions, coded waveforms, wideband operation, narrow beam widths, and evasive scan patterns without compromising accuracy and resolution. The term low probability of intercept refers to the small chance or likelihood of intercept actually occurring. The complexity and degrees of freedom available to modern radar place a high demand on electronic support systems to provide detailed and accurate real-time information. Intercept alone is not sufficient and this study focused on the detection, feature extraction (parameter estimation), and classification (using Fuzzy ARTMAP) of the Pilot Mk3 low probability of intercept radar. Fuzzy ARTMAP is a cognitive neural method combining fuzzy logic and adaptive resonance theory to create categories of class prototypes to be classified. Fuzzy ARTMAP systems are formed by self-organizing neural architectures that are able to rapidly learn and classify both discreet and continuous input patterns. To evaluate the suitability of a given electronic support intercept receiver against a particular low probability of intercept radar, the low probability of intercept performance factor is defined by combining the radar range, intercept receiver range, and sensitivity equations. The radar wants to force an opposing intercept receiver into its range envelope. On the contrary, the intercept receiver would ideally want to operate outside the specified radar detection range to avoid being detected by the radar. The maximum likelihood detector developed for this study was capable of detecting the Pilot Mk3 radar, as it allowed enough integration gain for detection beyond the radar maximum range. The accuracy of parameter estimation in an intercept receiver is of great importance, as it has a direct impact on the accuracy of the classification stage. Among the various potentially useful radar parameters, antenna rotation rate, transmit frequency, frequency sweep, and sweep repetition frequency were used to classify the Pilot Mk3 radar. Estimation of these parameters resulted in very clear clustering of parameter data that distinguish the Pilot Mk3 radar. The estimated radar signal parameters are well separated to the point that there is no overlap of features. If the detector is able to detect an intercepted signal, it will be able to make accurate estimates of these parameters. The Fuzzy ARTMAP classifier is capable of classifying the radar modes of the Pilot Mk3 low probability of intercept radar. 100% correct classification decisions are easily achieved for a variety of classifier configurations. Classifier training is quite efficient as good generalisation between input and output spaces is achieved from a training dataset comprising only 5% of the total dataset. If any radar has a low probability of intercept, there must be a consideration for the radar as well as the opposing intercept receiver. Calculating the low probability of intercept performance factor is a useful tool for such an evaluation. The claim that a particular radar has low probability of intercept against any intercept receiver is too broad to be insightful. This also holds for an intercept receiver claiming to have 100% probability of intercept against any radar.