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# Mathematical Neural Network (MaNN) Models
# Part III: ART and ARTMAP in OMNI_METRICS

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(Dedicated to Dr U Murali Krishna, former Special officer, A U P G center, Nuzvid, former Professor of [Analytical, engineering] department, Andhra University, on his *sahasra chandra darsanam* (thousand lunar months of life on the lap of mother earth).

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## ABSTRACT

*Adaptive resonance theory (ART) proposed by Grossberg in 1976, is a self-organizing (SO) unsupervised learning approach. It balances stability vs. plasticity dilemma in learning new traits without forgetting the old ones. Another popular SO mapping (SOM) of Kohonen introduced in 1990s subtly differs from ART and based on neighborhood influence. ART1-NN is the start of a new era of unsupervised-data-driven models using resonance, ordinary differential equations (ODEs) and backward connections. The main functioning of ART1 is in feature and category layers which are connected both ways. It accepts only binary input and makes use of winner-takes- all (WTA) and vigilance approaches. ART2 and fuzzy-ART are modifications of ART1 to handle analogue and floating point input values. ART3 performs a parallel search and incorporates a term similar to chemical transmitters playing a key role in biological system. The NNs reported over two decades in this category include coupled-, probabilistic-, projection-, performance-guided-, lateral-priming-, efficient-, fusion-ARTs. The philosophy of Grey relational analysis inspired from human brain is used in Grey-ART. Multiple channel data is analysed with multi-ART. Under hybrid category, SOM is used in fully-organized-SOM-ART and RBF in RBF-ART.*

*ARTMAP is a supervised learning procedure retaining the structure/function of ART as it is and contains ARTx and ARTy modules for binary input and output. Fuzzy-ARTMAP (fam) accepts floating point input as well as binary strings. Thus, ARTMAP and fuzzy-ARTMAP inherit advantages as well as shortcomings /pitfalls/limitations of ART. Both these NNs were put forward by Grossberg, Carpenter and their associates in early nineteen nineties. The efforts in the past 20 years are aimed at surmounting the ill effects of order of presentation of input patterns, noise and category proliferation which are the inherent limitations of ART. FAM is extended to function approximation task in FasART and FasBak and Marriott-FAMs. Instance counting-NN was proposed by Carpenter for medical diagnosis with*

*inconsistent data. Order-FAM surmounts the negative consequences of random order of presentation of input. In hyper-spherical- and Gaussian-FAMs, a kernel is used instead of a rectangular transfer function (TF). Parallel FAM is a fast training version for pipeline approach. Instar-, out-star-, distributed-, WTA, winner-takes-most (WTM), unsupervised-, semi-supervised-, self-supervised- learning methods are in practice. Auto-rule-discovery (ARD) and self-supervised-ARTMAP, a knowledge extraction and discovery tool are applied to satellite images. Other improvements in this category of NNs are Georgiopenlos-, Granger-, Charalampidis- Cascade-, Hierarchical-, probabistic-, adaptive-ARTMAPs and Bayesian-, Distributed-, GA-FAMs. The applications of ART-based NNs are widespread in chemistry, medical diagnosis, and engineering. The technology transfer to Boeing Corporation, MIT Lincoln laboratory for mega tasks is a gold standard test for its versatility and applicability and occupies a niche in the arsenal of data-driven non-parametric/AI paradigms.*

**Keywords:** Adaptive resonance theory (ART), Classification, Supervised-ART (ARTMAP), Binary, floating point data, fuzzy-ARTMAP, Inconsistent/contradictory input, Medical diagnosis, Chemical analysis, Auto-rule-discovery (ARD), Knowledge-extraction-discovery-satellite-images

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