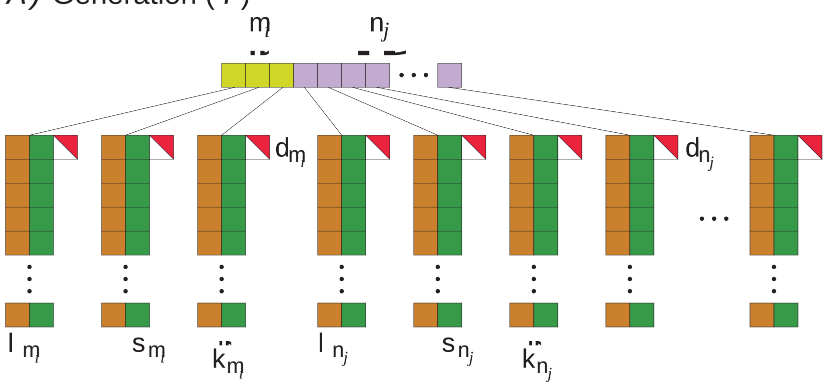
Maximum Likelihood Evolutionary Strategy for Image Reconstruction from Projections in ECT - Initial Investigation -

Outline of the MLES Reconstruction Algorithm

A) Generation (*I*)



B) Population recombination (crossover) $k_{n_j} = r(k_{m'}, k_{m''})$

C) Population mutation

$$d_{n_j} = \frac{\chi(c_{kl} \,|\, g_k, l_{n_j}^{(t)})}{\|c_l\|}$$ ML

D) Population sort $\max\{d_{n_j}\}$

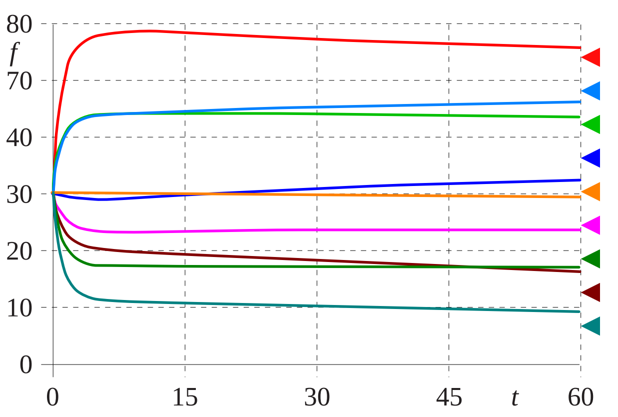
E) Generation (*II*) (comma strategy) $k_m \leftarrow k_{n_i}$

F) Evaluation (find fittest parent individual in generation)

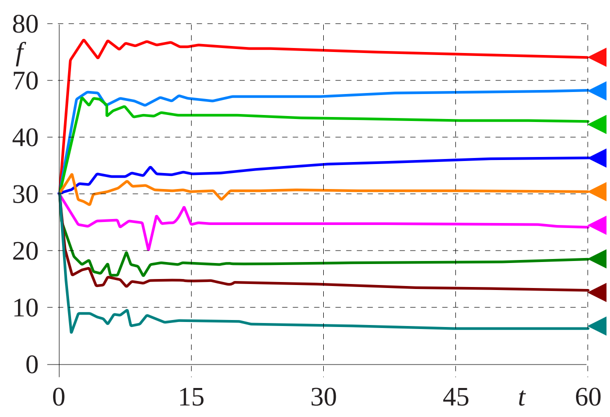
$$k_m^{*}(t) = \max\{d_m\}$$ MLES

Introduction: Evolutionary strategies are a class of methods primarily used for parameter optimization of an objective function such as the maximum likelihood function of Poisson distributed data. Evolutionary strategies incorporate the principles of population, recombination, mutation, and selection from biologic evolution as the major heuristics. In contrast to traditional gradient methods, which converge very often into some locally optimal solution, evolutionary strategies are able to find the global optimum due to the use of distributed mutations and recombination. As with the synergetic approach, evolutionary algorithms could be used in multi-objective optimization which make this theory interesting for image reconstruction. Although preliminary experiments show some interesting results, it remains questionable (data statistics, dimension of the solution space) if this strategy can be used for image reconstruction.

Comparison and First Results



MLEM: Dynamics of voxel values for a 3x3 reconstruction problem (four projections) using MLEM. Noise-free projection data have been calculated and the true original activity values are marked by triangles on the right side of the plot. Using the same stopping criterion as in the right plot, the algorithm converges after more than 200 iterations.



MLES: Dynamics of voxel values for the same problem shown in the left figure, but using an evolutionary strategy. The algorithm satisfied the stopping criteria after 45 iterations (generations). The genetic processes moved the system quickly to the maximum likelihood. As the stochastic forces relax over time, the algorithm will converge into the ML solution.