GENETIC ALGORITHM TUNED CONSTANT GAIN KALMAN FILTER APPROACH FOR ESTIMATION OF IONOSPHERIC TEC AND DIFFERENTIAL INSTRUMENTAL BIASES USING DUAL FREQUECNCY GPS OBSERVATIONS

R. Anandraj[1], **M. R. Ananthasayanam**[2], **P.R.Mahapatra**[3], **and P. Soma**[4]

[1,4]*ISRO Telemetry, Tracking and Command Network, Bangalore 560058, India,*
emsraju@rediffmail.com, *soma@istrac.org*

[2]*c/o Department of Aerospace Engineering, Indian Institute of Science, Bangalore 560012, India,*
sayanam@aero.iisc.ernet.in

[3] *Department of Aerospace Engineering, Indian Institute of Science, Bangalore 560012, India,*
pravas@aero.iisc.ernet.in

Key Words: TEC, Genetic Algorithm, Constant Gain Kalman Filtering

SUMMARY

Genetic Algorithms (GA) have received a great deal of impetus due to their enormous capability for handling complex optimization problems. These are search algorithms based on the mechanics of natural selection as in genetics. They combine the survival of the fittest with a structured yet randomized information exchange to form a search algorithm. The GA can be considered as a stochastic optimization technique where the search methods model natural phenomena of genetic inheritance and Darwinian strife for survival and natural evolution.

In many science and engineering applications using the Kalman filter there could be unmodellable errors in the governing state and measurement equations of many systems. In such cases due to the introduction of process noise in the filter state equations the Kalman gain matrix elements tend to nearly a constant value after an initial transient. This observation provides a possible Kalman filter tuning approach in which instead of adaptively tuning P_0, Q and R respectively the initial state, process, and measurement covariances generally a smaller number of Kalman gain elements can be worked out. Another advantage of the Constant Gain Kalman Filter (CGKF) approach in dealing with the cost J function of the filter is that one need not propagate the covariance equations, which are responsible for the large computational load. The acceptable statistical consistency of the results from the adaptive technique and the constant Kalman gain approach provides the confidence in the latter procedure. There could be slight differences in the gain values between the above approaches due to the relative periods of the transient and the steady state conditions. In the present work dealing with the Ionospheric Total Electron Content (TEC) following Sardon et al formulation, the estimation of the above gains based on the cost function of the Kalman Filter utilizes the Genetic Algorithm.

The Genetic Algorithm turns out to be efficient due to features like the coding of the parameter set and not the parameter themselves, uses cost but not the gradients of the cost function, and utilizes probabilistic and not deterministic transition rules. In a simple Genetic Algorithm an initial generation of individuals are randomly chosen in the search space. The next generation is created after applying three operators in their order of execution such as (i) R*eproduction:* Individuals are copied to the next generation with probability relative to their fitness, (ii) *Crossover:* Pairs of strings drawn randomly from the population are subjected to crossover. They are randomly paired to create two new descendants. For each pair a crossover location in the bit string is selected at random, which divides the string into two parts. Swapping the remainder of the two strings with each other does crossover, and (iii) *Mutation:* After mutation a bit is randomly selected within the chromosome string and mutated. The termination criteria could be after a fixed number of generations, or the change in fitness value between populations.

The following are the various steps adopted for the implementation of GA. Choose coding to represent problem parameters and the criteria for Reproduction, Crossover and Mutation, as well as the initial population size, probabilities of cross over and mutation, search domain of the variables, termination criteria. Set T=0, generate initial population from the search domains randomly. Evaluate each string of the

population for fitness. If Termination Criteria is satisfied then STOP. Perform reproduction, crossover, and mutation on the population and evaluate the strings of the new population. The parameters used in the present GA implementation after some trial and error are the Population size = 200; Bit Length = 20; Probability of Cross Over = 0.90; Probability of Mutation = 0.05; Convergence: Number of generations = 50 or alternately change in J between generations = 0.0001. This paper describes the formulation of GA tuned constant gain Kalman filter for the estimation of TEC and instrumental biases over Indian region.

REFERENCES

1. Sardon E, Rius A, and Zarraoa N, " Estimation of the transmitter and receiver differential biases and the ionospheric total electron content from Global Positioning System observations", Radio Science, Vol. 29, Number 3, pp. 577-586, May-June 1994.
2. Myers K.A and Tapley B.D., "Adaptive Sequential Estimation With Unknown Noise Statistics", IEEE Trans automatic Control, Vol. AC 21, pp 520-525, 1976.
3. Gemson R.M.O and Ananthasayanam M.R., "Importance of Initial State Covariance Matrix For The Parameters Estimation Using An Adaptive Extended Kalman Filter", Proc. AIAA Conference on Atmospheric Flight Mechanics, AIAA-98-4153, 1998.
4. Coco D.S, C.Coker, S.R.Dahlke and J.R.Clynch, "Variability of GPS satellite differential group delay biases", IEEE Trans. Aerospace. Electron. Syst., 27(6), 931-938,1991.
5. Whitely, L.D (ed.), "Foundations of Genetic Algorithm. 2", Morgan Kauffmann Publishers, 1993.
6. Deb, K., "Optimization of reengineering Design: Algorithms and Examples", Prentice Hall of India, 1995