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THE PHILOSOPHY, PRINCIPLES, AND PRACTICE OF KALMAN FILTER SINCE ANCIENT TIMES TO THE PRESENT IN ASTRONAUTICS

Abstract

The conceptual basis for the ubiquitous Kalman filter can be traced since ancient times. It progress is similar to any physical theory moving randomly across intuitive beginning, applications or experiments, and mathematical framework. The triplets of change, capture, and correct forms the conceptual basis for Kalman filter. Similar to many other brilliant scientific discoveries its development has gone through controversies of priority as stated by Arnold, Berry, or Whitehead laws. The reason for the above being a large number of competent people are working around the same time and concepts float like gas molecules, condense, and finally crystallize. During the periods of rapid development be in mythological, medieval, or modern periods its connection with celestial objects is remarkable. The ancient Indian astronomers since 500 AD used it to update the parameters for predicting the position of celestial objects for timing their Vedic rituals, the asteroid Ceres sighted by Piazzi on the first day of 1801 tracked for 41 days and subsequently lost was helped by Gauss to be sighted on the last day of that year, and during mid twentieth century the formulation by Kalman helped the Apollo project to the Moon. Presently the scale and magnitude of many difficult and interesting problems it has been able to handle could not have been contemplated by ancient Indian astronomers, Gauss or Kalman. There are many interesting perspectives in which the Kalman filter can be understood. One is as a sequential statistical analysis of a random process. Another is it is a recursive least squares together with an evolving system dynamics between measurements. The unpretentious splitting of state and measurements, and switching between the former and update using the latter leads to interesting possibilities like 'wholes are more than the sum of their parts' as stated by Minsky. Typical applications in astronautics include target tracking, evolution of the space debris scenario, fusion of GPS and INS data, study of the tectonic plate movements, and atmospheric data assimilation. However in spite of its attractive nature the design of a Kalman filter depends on the difficult tuning of the initial state, process, and measurement noise covariances. The present paper discusses how many involved problems can be handled by variants of the basic filter formulation to overcome the above difficulty. Finally as an analogy the implications of the filter statistics from examples in science and society are also provided.