Systems Analysis: Modeling and Control

International Conference in memory of
Academician Arkady Kryazhimskiy

Ekaterinburg, Russia, 3–8 October 2016

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In the case of $v = \frac{\beta}{u_x+\gamma-1}$ we have $V(1-\rho C_x) = G(\gamma-\rho C_x)^\beta$, then the model has a form

$$C_t + \frac{\sigma^2 x^2 C_{xx}}{2\left(1 - \frac{\beta\rho x C_{xx}}{\gamma-\rho C_x}\right)^2} + r(xC_x - C) = 0.$$

It has invariant solutions

$$C(t,x) = Ae^{rt}\left(\ln x + \frac{\sigma^2 t}{2(1-\beta)^2} - rt + B\right) + \frac{\gamma}{\rho}x,\ A \neq 0,\ \beta \neq 1;$$

$$C(t,x) = Ae^{t\left(\frac{\sigma^2\alpha(1-\alpha)}{2(\beta(\alpha-1)+1)^2} + r(1-\alpha)\right)}x^\alpha + Be^{rt} + \frac{\gamma}{\rho}x,$$

$$A \neq 0,\ \alpha \neq 0,\ \alpha \neq 1 - \frac{1}{\beta}.$$

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References

[1] *Black, F., Scholes, M.* The pricing of options and corporate liabilities. Journal of Political Economy, 81, 637–659 (1973).

[2] *Sircar,K.R., Papanicolaou, G* General Black—Scholes models accounting for increased market volatility from hedging strategies. Appl. Math. Finance, 5, 45–82 (1998).

Multi-hypothesis tracking algorithm for aircraft trajectory

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The paper is devoted to the problem of aircraft trajectory recovery by using incoming radar measurements. Here, we mean not a posteriori recovery of the trajectory but the on-line operation. Namely, immediately after the arrival of the next radar measurement, the elaborated algorithm yields the assessment of the aircraft location.

We study a particular case of an aircraft motion in the horizontal plane; the Earth's surface curvature and the aircraft altitude above the surface of the Earth are not taken into account. Also, it is supposed that the identification problem is solved; i.e., the radar measurements are related to one and the same aircraft.

The algorithm under consideration performs the construction of a bundle of trajectories that are the most "likely" versions of trajectory motions of the aircraft. If recalculated, the radar measurements are tracked in time in the sliding window in order to present different variants of the motion of the aircraft that are compatible with its dynamical possibilities. When the next measurement arrives, the operation of recalculating the bundle of tracks consists in sequential starting and performing of the following procedures: bundle branching; generation of assessment of the current location of the aircraft; grouping and pruning of the bundle; and (possibly) optimization of the bundle of trajectories.

In the simulation, we use the standard industry model of motion model of motion that is the system of ordinary differential equations of the fourth order. The system describes the trajectory motion of the aircraft in the horizontal plane with restrictions on the longitudinal and lateral accelerations:

$$\begin{aligned}
\dot{x} &= v\cos\varphi, \\
\dot{z} &= v\sin\varphi, \\
\dot{\varphi} &= u/v, \\
\dot{v} &= w.
\end{aligned}$$

Here, x and z are coordinates of the geometric location in the plane; φ is the angle between the velocity vector and the x-axis (track angle); v is the magnitude of velocity ($v > 0$); u is the lateral acceleration ($|u| \leq u_{\max}$); w is the longitudinal acceleration ($|w| \leq w_{\max}$). The accelerations are assumed to be time-variable control parameters unknown to the observer.

The initial "start-up" of the algorithm is performed using different sets of measurements from their initial input sequence.

The procedure of branching (which is necessary for supporting the representativity in the calculated bundle of trajectories) uses both precise aiming at a newly received measurement and aiming at some set of random points around the measurement.

For grouping and pruning the bundle of trajectories, we solve the problem of limiting the total number of tracks with the choice of the most typical "likely" motions. Here, known methods of cluster analysis are used.

The optimization procedure for individual representatives of the bundle of trajectories gives the possibility to reduce error in the algorithm work of generating a current evaluation for the location of the observed object.

We study several variants of calculation of the coefficient of agreement between the trajectory of the bundle and available measurements including issues of stability to possible "outliers" in the radar measurement data. The agreement coefficient defines the future of a trajectory from the bundle. Namely, trajectories with a good agreement coefficient remain in the bundle, while trajectories with poor agreement coefficient are removed from it. This coefficient may include penalties for the use of controls that do not correspond to the hypotheses and penalties for frequent changes of the control values.

To form an estimation of the aircraft location, we can apply coefficients of agreement of the bundle to the measurements that are different from the coefficients used to prune the bundle.

The accuracy of the algorithm work is analyzed with model data. The results of the work on real tracks of the radar are also presented.

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Dynamics of set-valued estimates of reachable sets of control systems with uncertainty and nonlinearity

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We consider the problem of estimating reachable sets of nonlinear dynamical control systems with uncertainty in initial states when we assume that we know only the bounding set for initial system positions and any additional statistical information is not available. We study the case when the system nonlinearity is generated by the combination of two types of functions in related differential equations, one of which is bilinear and the other one is quadratic. The problem may be reformulated as the problem of describing the motion