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COLLEGE OF ENGINEERING
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Research Horizons Day

Hybrid-Impulsive Higher Order Sliding Mode Control in Reduced Information Environment

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Overview

A hybrid-impulsive second order/higher order sliding mode (2-SMC/HOSM) control is explored in order to reduce dramatically the convergence time practically to zero, achieving instantaneous (or short time) convergence and uniformity. For systems of relative degree 3, the impulsive portion of the control function drives the system's output (the sliding variable) and it's derivative to zero instantaneously (or in short time) achieving a uniform convergence. Then the discontinuous state or output feedback stabilizes system's trajectory at the origin (or its close vicinity), while achieving the ideal or real second order sliding mode (2-SM). Two hybrid-impulsive 2-SMCs are studied in systems of *arbitrary relative degree* in a *reduced information environment*. Only "snap" knowledge of the all states is required to facilitate the impulsive action. The efficacy of studied hybrid-impulsive control algorithms is illustrated via simulations. The insensitivity and finite time convergence properties enjoyed by sliding mode controllers (SMC) make them a useful approach for systems with bounded perturbations.

1. Objectives

Consider the following perturbed system of arbitrary relative degree

$$\dot{x} = Ax + B(\Delta f + v_1), \quad x(0) = x_0$$

The objectives of this research are:

1. Study a *continuous* HOSM (CHOSM) control in perturbed systems of *arbitrary relative degree* with impulsive action in order to reduce dramatically the convergence time practically to zero, achieving almost instantaneous convergence and uniformity.
2. Study a hybrid-impulsive second order sliding mode control (2-SMC) in perturbed dynamic systems of arbitrary relative degree in a reduced information environment. Only last one or two variables in system are assumed available.

2. Hybrid-Impulsive HOSM control design

Studying the given system with relative degree $r = 3$, assuming that only $x_3(t)$ is available, then the impulsive super-twisting control is given by $v_1(t) = v_{STW}(t) + v_{imp\_h}(t)$

$$v_{imp\_h} = \sum_{k=0}^{r-1} q_k \delta_h^{(k)}(t)$$, and the super-twisting control is

$$\begin{cases} v_{STW} = -\alpha |x_3|^{1/2} sign(x_3) + w \\ \dot{w} = -\beta\, sign(x_3) \end{cases}, \quad \text{where } \alpha, \beta > 0, \text{ and } q_k, k = 0,1,2$$

$$[q_0, q_1, q_2]^T = -[B, AB, A^2 B]^{-1} exp(A\varepsilon) x_0$$

the Dirac delta function is approximated as a piece-wise constant of delta function

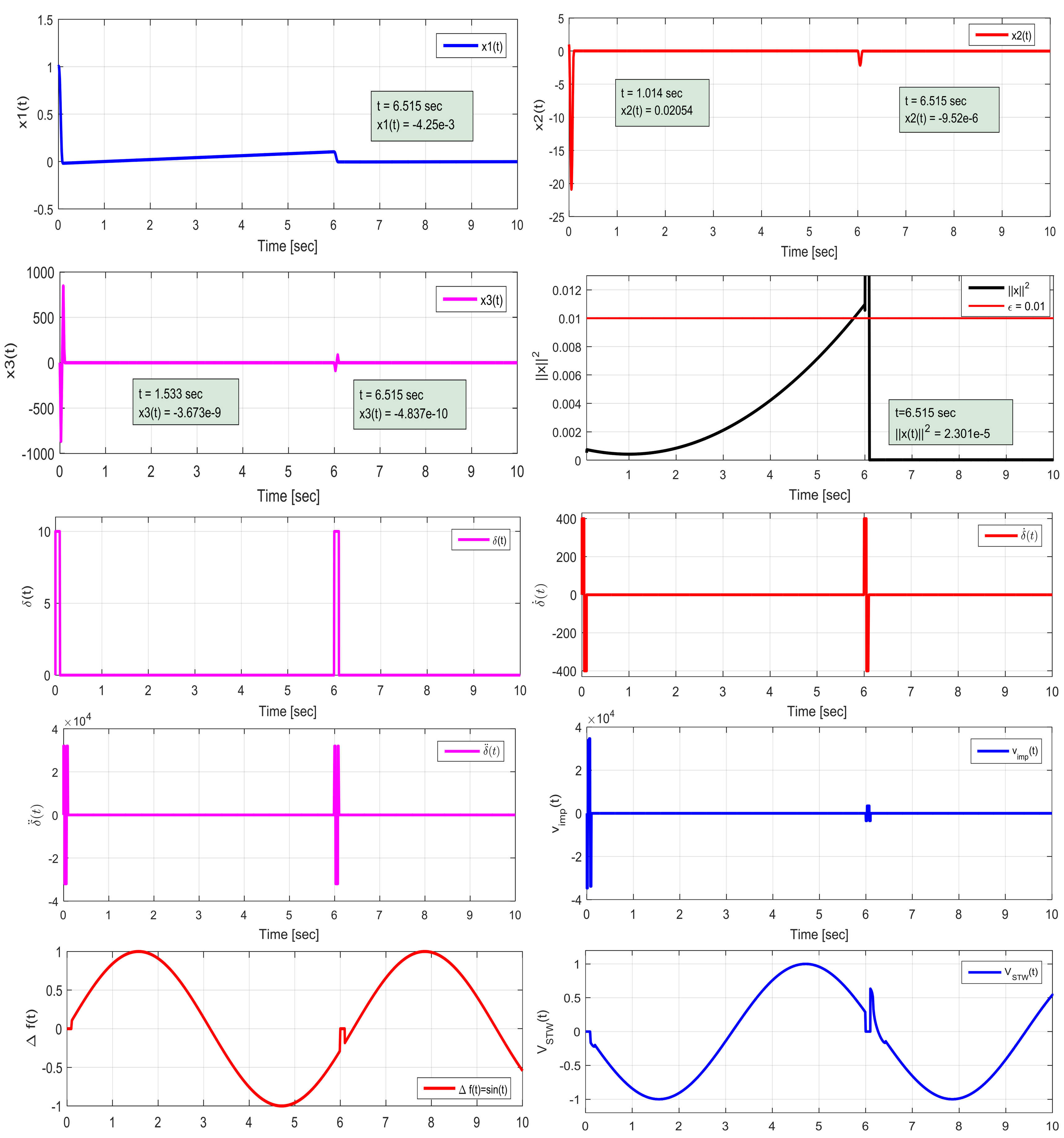
$$\delta_h(t) = \begin{cases} \frac{1}{h}, & if \ \ 0 \le t \le h \\ 0, & otherwise \end{cases},$$ and its higher derivatives can be approximated as

$$\delta_h^k(t) = \frac{\delta_{h/2}^{(k-1)}(t + h/2) - \delta_{h/2}^{(k-1)}(t)}{h/2}, \ k \ge 1$$

and the disturbance is $$\Delta f(t) = \begin{cases} 0, & if \ t \in [0, h] \\ \sin(t), & if \ t \ge h \end{cases}$$

The goal of the impulsive control $v_{imp\_h}(t)$ is to derive $x(t) \to 0$ by the time $t = h$

3. Simulation Results



4. Conclusion

In systems of *arbitrary relative degree* in a *reduced information environment* two hybrid-impulsive 2-SMCs are studied. Only last *one or two* system variables are assumed available. Snap knowledge (or knowledge in a single time instant) of the all states is required in order to facilitate the effective impulsive action. The efficacy of studied hybrid-impulsive control algorithms are illustrated via simulations.

5. References

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