Procedures to implement the control technique developed in EJCON_2017_243

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Procedure 1 Topological graph matrices

procedure TOPOLOGYINFO
Define the topology represented by figure 2 via graph matrices
Define graph matrices $\mathcal{A}$, $\mathcal{B}$, $\mathcal{D}$
Calculate graph Laplacian
    $\mathcal{L} \leftarrow \mathcal{D} - \mathcal{A}$
Calculate topology defining matrix
    $\mathcal{H} \leftarrow \mathcal{L} + \mathcal{B}$

Procedure 2 Definition of tracking error variables

procedure TRACKINGERROR
Compute position and velocity states of leader $(x_0(t), v_0(t))$
Compute position and velocity states of followers $(x_i(t), v_i(t))$
Define error in position state (refer 9)
    $e_{x_i}(t)) \leftarrow x_i(t) - x_0(t)$
Define error in velocity state (refer 10)
    $e_{v_i}(t)) \leftarrow v_i(t) - v_0(t)$
Get $\mathcal{H}$ from procedure 1
Formulate topological errors in position and velocity (refer 11, 12)
    $\bar{e}_{x_i}(t) \leftarrow \mathcal{H}(x_i(t) - x_0(t))$
    $\bar{e}_{v_i}(t) \leftarrow \mathcal{H}(v_i(t) - v_0(t))$

Procedure 3 Determination of triggering instants

procedure TRIGGERINGRULE
Define α_1, α_2, β_1, β_2
Formulate δ (refer 43)
    if $\delta > 0$ **then**
        $t \leftarrow t^k$
        $t^{k+1} \leftarrow \inf\{t_i \in [t_i^k, \infty[\ : \delta \geq 0\}$
        $u(t) \leftarrow u(t^k)$
    else
        $u(t) \leftarrow$ previous value of $u(t)$

Procedure 4 Discretization of variables

procedure DISCRETIZATION

Get $t = t^k$ instants from the previous procedure

Define discretization error in position state (refer 24)

  $\bar{\epsilon}_x(t) \leftarrow x(t) - x(t^k)$

Define discretization error in velocity state (refer 25)

  $\bar{\epsilon}_v(t) \leftarrow v(t) - v(t^k)$

Calculate e_{x_i} at $t = t^k$ (refer 26)

  $e_{x_i}(t^k) \leftarrow x_i(t^k) - x_0(t^k)$

Calculate e_{v_i} at $t = t^k$ (refer 27)

  $e_{v_i}(t^k) \leftarrow v_i(t^k) - v_0(t^k)$

Calculate $\tilde{e}_{x_i}$ at $t = t^k$ (refer 28)

  $\tilde{e}_{x_i}(t) \leftarrow e_{x_i}(t) - e_{x_i}(t^k)$

Calculate $\tilde{e}_{v_i}$ at $t = t^k$ (refer 29)

  $\tilde{e}_{v_i}(t) \leftarrow e_{v_i}(t) - e_{v_i}(t^k)$

Procedure 5 controlProtocol

procedure COMPUTATION OF THE CONTROL PROTOCOL

Define λ, K, m, w, ς_i, ς_0

Formulate sliding manifold σ (refer 14)

  $\sigma \leftarrow \bar{e}_{v_i}(t) + \lambda \bar{e}_{x_i}(t)$

Calculate derivative of surface variable

  $\dot{\sigma}_i(t) \leftarrow \mathcal{H}(\dot{v}_i(t) - \dot{v}_0(t)) + \lambda \mathcal{H}(\dot{x}_i(t) - \dot{x}_0(t))$

Replace $\dot{\sigma}_i(t)$ in the above expression by the reaching law

  $\dot{\sigma}_i(t) \leftarrow -K \ \sinh^{-1}(m + w|\sigma_i(t)|) sign(\sigma_i(t))$

Compute the control $u(t)$ from the above relations (refer 15)

Depending upon whether δ is positive, i.e, $u(t)$ is updated

  if $\delta > 0$ **then**

    $u(t) \leftarrow u(t^k)$

  else

    $u(t) \leftarrow$ previous value of $u(t)$