init()

- controller state $\mathbf{C} = \textbf{TRAJ}$
- number of joints J
- noise threshold ϵ
- joint times $\mathbf{t}_{i,0} = 0 \; \forall i \in J$
- joint states $\mathbf{j}_{i,0} =$ NO_CONTACT $\forall i \in J$
- forces $\mathbf{f}_{i,0}$ s $\mathbf{f}_{i,t-1} = 0 \; \forall i \in J$
- feather constant estimator $\bar{k}_{i,0} = 0 \; \forall i \in J$

update(Period p)

update_sensors();

// update joint states & timing

for i in $[0...J-1]$ **do**

  if $\mathbf{f}_{i,t-1} \leq \epsilon$ **&&** $\mathbf{f}_{i,t} > \epsilon$ **then**

    $\mathbf{s}_{i,t} =$ GOT_CONTACT

  else if $\mathbf{f}_{i,t-1} > \epsilon$ **&&** $\mathbf{f}_{i,t} \leq \epsilon$ **then**

    $\mathbf{s}_{i,t} =$ LOST_CONTACT

  else if $\mathbf{f}_{i,t-1} > \epsilon$ **&&** $\mathbf{f}_{i,t} > \epsilon$ **then**

    $\mathbf{s}_{i,t} =$ IN_CONTACT

  else

    $\mathbf{s}_{i,t} =$ NO_CONTACT

  end

  if $\mathbf{s}_{i,t} ==$ NO_CONTACT || $\mathbf{s}_{i,t} ==$ LOST_CONTACT **then**

    $\mathbf{t}_{i,t} \leftarrow \mathbf{t}_{i,t} + p$

end

// update controller state

if $\mathbf{C} ==$ **TRANS then**

  $\mathbf{C} =$ **F_CTRL**

else if $\mathbf{C} ==$ **TRAJ then**

  if check_controller_transition() then

    $\mathbf{C} =$ **TRANS**

    for i in $[0, J-1]$ **do**

      $\mathbf{f}_{i,T} \leftarrow \mathbf{f}_{i,t}$

      $\mathbf{j}_{i,T} \leftarrow \mathbf{j}_{i,t}$

    end

// joint position calculations

for i in $[0, J-1]$ **do**

  if $\mathbf{C} ==$ **TRAJ** || $\mathbf{C} ==$ **TRANS then**

    $\mathbf{j}_{\text{des}_{i,t}} \leftarrow$ **sample_trajectory_for_joint**(Joint i, Time $\mathbf{t}_{i,t}$)

  else

    // calculate new deltas, estimate $\bar{k}$ and calculate new $\mathbf{j}_{\text{des}_{i,t}}$

    TIAGo

$$\Delta \mathbf{f}_{i,t} = \mathbf{f}_{i,t} - \mathbf{f}_{i,T}$$
$$\Delta \mathbf{j}_{i,t} = \mathbf{j}_{i,t} - \mathbf{j}_{i,T}$$

$$k_{i,t} = \frac{\mathbf{f}_{i,t}}{\mathbf{j}_{i,t}}$$
$$\bar{k}_{i,t} = (1-\lambda) k_{i,t} + \lambda \bar{k}_{i,t}$$

$$\mathbf{f}_{\text{des}_{i,t}} = 1.1 * \mathbf{f}_{\text{max}_i} - \mathbf{f}_{i,t}$$
$$\mathbf{j}_{\text{des}_{i,t}} = \frac{\mathbf{f}_{\text{des}_{i,t}}}{\bar{k}_{i,t}} + \mathbf{j}_{i,t}$$

    Shadow

$$-$$ (1)

  end

end

publish_debug_info();

// check if the goal is finished

if $\mathbf{C} ==$ **TRAJ then**

  if last Segment successfully executed **then**

    goal_succeeded();

else

  if $\mathbf{f}_{i,t} \geq \mathbf{f}_{\text{max}_i} \forall i \in [0, J-1]$ **then**

    force_finished();

    goal_succeeded();

end

// store data for next loop

for i in $[0, J-1]$ **do**

  $\mathbf{f}_{i,t-1} \leftarrow \mathbf{f}_{i,t}$

  $\mathbf{s}_{i,t-1} \leftarrow \mathbf{s}_{i,t}$

end

Algorithm 1: Platform-Independent Force Controller