Brief summary of the invariants and models for the 4mob robot

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- The robot must not fall

  - Left/right balance:
    Variables:
    α : left/right balance angle
    Op : operator informed (0: operator not informed, 1: operator informed)
    Interventions:
    $alarm : next(Op) = 1$

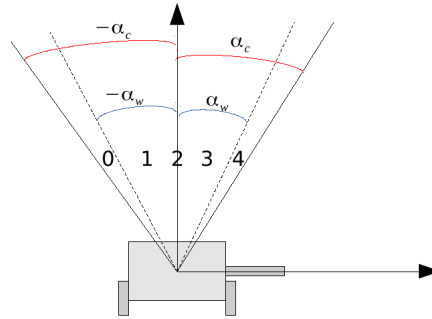 $cata : (\alpha = 0$ or $\alpha = 4)$ and $Op = 0$

Figure 1: Left/right balance

  - Front/back balance:
    Variables:
    β : front/back balance angle
    Op : operator informed (0: operator not informed, 1: operator informed)
    Interventions:
    $alarm : next(Op) = 1$

    $cata : (\beta = 0$ or $\beta = 4)$ and $Op = 0$
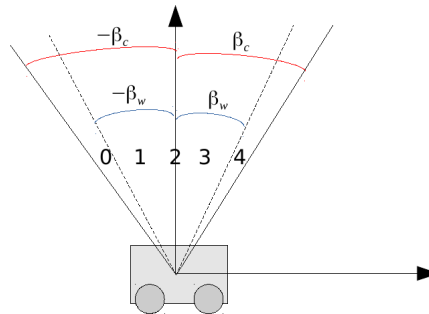

Figure 2: Front/back balance

- The robot must not enter a prohibited zone:
  Variables:
  d : distance to the prohibited zone (0 : too close to the prohibited zone, 2 : far from the prohibited zone)
  Interventions:
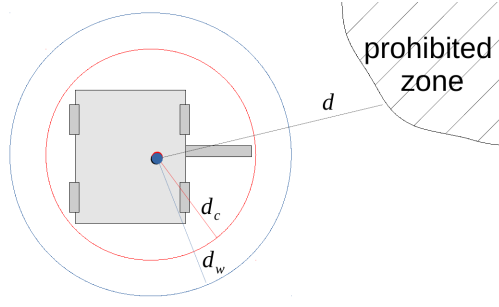
$brake : next(d) \neq 0$

$cata : d \leq d_c$

Figure 3: Prohibited zone

- The communication between the robot and the operator must always be operational: Variables:
  v : speed of the robot
  t_{comm} : time since the loss of the communication (0: the communication is good, 2: the communication has been lost for a long time)
  Interventions:
  $full\_stop : next(v) = 0$

  $cata : t_{comm} = 0$ and $v = 1$

- The robot must not exceed a certain linear speed: Variable:
  v : linear speed of the robot
  Intervention:
  $brake : next(v) \neq v + 1$

  $cata : v = 2$

- The robot must not exceed a certain angular speed: Variable:
  ω : angular speed of the robot
  Intervention:
  $brake : next(\omega) \neq \omega + 1$

  $cata : \omega = 2$

- The robot must not collide with an obstacle:

  - Single obstacle model:
    Variables:
    x : abscissa of the obstacle on the robot's referential
    y : ordinate of the obstacle on the robot's referential
    v : speed
    $type_{obst}$: type of the obstacle (high or low)
    Interventions:
    $full\_stop : next(v) = 0$
    $inhib\_rotation : next(x) = x$

    $cata : v \neq 0$ and $(x = 2$ and $y = 2$ and $type_{obst} = 0$ or $(x = 2$ or $x = 3)$ and $y = 2$ and $type_{obst} = 1)$

  - Multiple obstacles model:
    Variables:
    $z1$: presence of an obstacle on the front or on the side opposed to the arm
    $z2$: presence of an obstacle in front of the arm and type of the obstacle (high or low)
    $z3$: presence of an obstacle on the side of the arm and type of the obstacle
    $z4$: presence of an obstacle on the platform
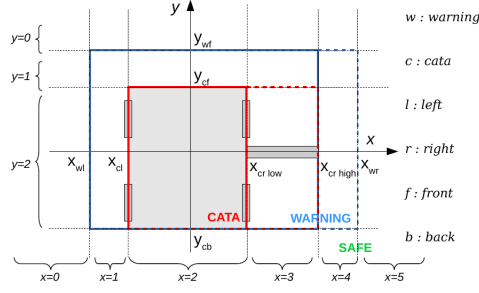 $z5$: presence of an obstacle in the arm's zone and type of the obstacle

Figure 4: Single obstacle model

v : speed of the robot
Interventions:
$full\_stop : next(v) = 0$
$inhib\_curve$: if there is no high obstacle close, then $next(z4) = 0$
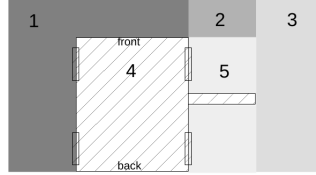
$cata : (z4 = 1$ or $z5 = 1)$ and $v \neq 0$

Figure 5: Multiple obstacles model

- The robot must not back away:
  Variables:
  $speed$: speed of the robot (0: reverse, 1: motionless or 2: forward)
  Interventions:
  $inhib\_reverse : next(speed) \neq 0$

  $cata : speed = 0$

- The radius of curvature of the robot must not exceed a certain value:
  Variables:
  $radius$: radius of curvature (0 : important radius of curvature on the left, 4 : important radius of curvature on the right)
  Interventions:
  $restrict\_curve : next(radius.v) \neq 0$ and $next(radius.v) \neq 4$

  $cata : radius = 0$ or $radius = 4$